A HIGH RESOLUTION INTEGRATED COMBAT AND LOGISTICS MODEL (STAR-LOG)

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THESIS

A HIGH RESOLUTION INTEGRATED COMBAT
AND LOGISTICS MODEL
(STAR-LOG)

by

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and

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March 1980

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I. INTRODUCTION

It is predicted that future warfare will be intense and extremely destructive. In this environment, combat units may have to operate in essentially continuous combat for sustained periods of time. Survival will depend more than ever on firepower and mobility. Due to the high consumption of ammunition and fuel predicted for this type of warfare, the ability to resupply the combat unit may well become a critical factor in the outcome of the war.

This thesis is an attempt to modify the current brigade level Simulation of Tactical Alternative Responses (STAR) combined arms model [Ref. 1] to portray the ammunition and fuel resupply process as an integral part of the brigade battle. This expanded model will allow the analysis of the direct interactions of logistics and combat at a high level of resolution.

The philosophy in developing this document has been to make the methodology as broad and as transparent as possible. The model design is offered for intial use by the analytical community as a possible means of evaluations intra-battalion assets, organizations and operations. Areas of specific investigation could include the practicality of an armored forward area rearm/refuel vehicle, the feasibility of various resupply tactics or the location of critical supply points.

The model is also expected to provide an interface between logistics and combat models. The ammunition supply

point (ASP) has been modeled in detail by the Ammunition Supply Point Requirements and Evaluation Model (ASPREM) and work continues on modeling other areas of the ammunition and fuel supply system. Combat models are used extensively in the cost and operational effectiveness analysis performed for items of proposed or modified hardware such as the advances attack helicopter, the XM-1 tank and the infantry fighting vehicle (IFV). With this model it would be possible to access concurrently the combat and logistical effectiveness of a unit due to changes in tactics or weapons systems. For example, it could determine if the ASP could provide timely ammunition support of a new weapons system in the context of a combined arms battle.

The STAR model is well suited for the addition of the logistics module because, as a discrete event simulation, it has the degree of resolution necessary to model the shooter/supplier interface. It is an active combat simulation large enough to model the major systems of a BLUE brigade including the logistics. The simulated terrain currently consists of a forty by sixty kilometer section of the Fifth U.S. Corps in Europe. This area is large enough to accurately depict the array of combat and logistics units in a brigade area. As a result of being in the same area with the combat units, the logistical units are vulnerable to the effects of air, artillery and direct fire weapons. The model is also extremely flexible due to its ability to vary, through user input, combat tactics, unit composition and vehicle characteristics.

When the research began, it was believed that the primary effort would be to model the ASP, the ammunition transfer point (ATP) and the petroleum, oil and lubricant (POL) point in the brigade support area (BSA). Although these facilities needed to be included in the model, they turned out not to be the primary problems. It was soon determined that the most important problem to be resolved was how to model the combat commanders decision logic concerning the requisition and allocation of ammunition and fuel in a combat situation. To do this required that the logistics module be fully integrated into the combat model.

Chapter II provides a general explanation of the logistical process incorporated into STAR, the programming language used in STAR and the utilization of the Software Design and Documentation Language (SDDL).

Chapter III discusses in detail the logic modelled in each part of the logistics module. The routines and events which make up the logistics module are listed in Appendix A using the SDDL format.

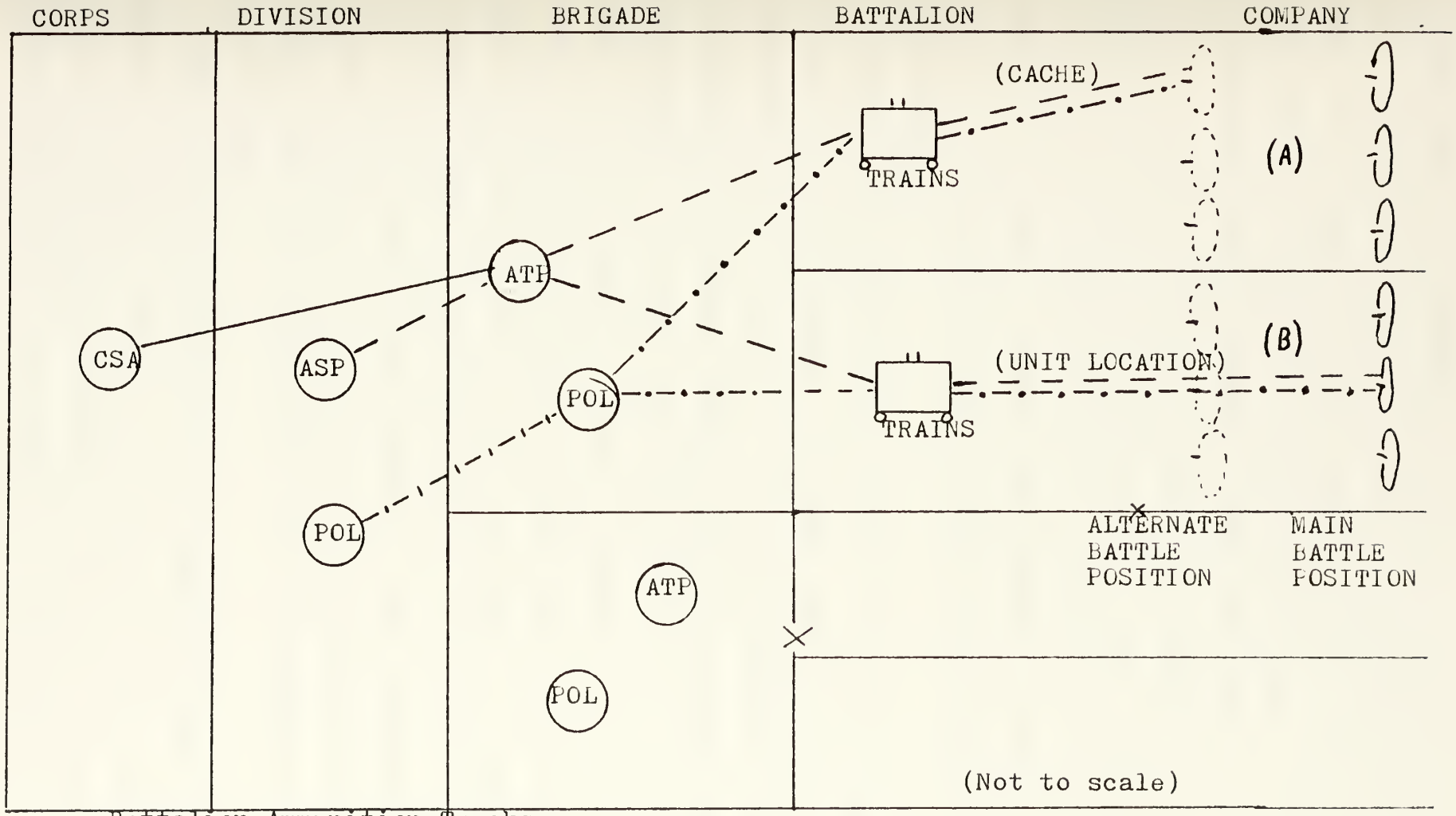
II. BACKGROUND INFORMATION

A. LOGISTICS SUPPORT OF A BRIGADE

The resupply of fuel and ammunition is a complex process directly involving elements of the battalion, brigade, division or corps. All these organizations focus toward the combat battalions. Before outlining the resupply process, it it best to look at the basic element of the entire process, the battalion support platoon.

The typical support platoon is organized with three sections: platoon headquarters, ammunition/transportation section and fuel section. The fuel section is composed exclusively of tactical fuel trucks. All the battalion's fuel is stored in these trucks. The actual number and design of the individual vehicles may vary from unit to unit. The ammunition/transportation section is normally composed of standard tactical cargo trucks. The dual title is used to indicate that the section may have missions other than hauling ammunition. It is the general mission of the support platoon to carry the battalion's basic load, resupply the combat user from this stock and replenish the basic load at brigade, division and corps issue points.

The infrastructure shown in figure 1 delivers, stores and issues resources above the support platoon level. It is best examined when separated into fuel and ammunition. The division support command (DISCOM) provides a bulk petroleum, oil and lubricant (POL) issue point for each



- - - Battalion Ammunition Trucks
-•-•- Battalion Fuel Trucks
-|-|- DISCOM POL Tankers
——— Corps Ammunition Convoys

Figure 1 Diagram of the Ammunition and Fuel Support Structure

brigade area by positioning organic POL tankers forward. This POL point is usually located in the brigade support area, out of range of threat medium artillery and provides area support for all units in the brigade area. It is usually 100 percent mobile so that it can move frequently to maintain a position to provide forward fuel support for the combat battalions of the brigade and to avoid indirect fire. The brigade POL point is normally composed of line haul tankers which have a limited cross country capability. It is tailored to provide support based on anticipated fuel requirements.

When a fuel tanker at the brigade POL point is empty, it returns to the division POL point, which is located in the DISCOM area, to refill. The DISCOM POL point is normally composed of linehaul tankers and ground mounted collapsible bladders. It usually has the capability to store at least one day of supply. Since the majority of the bulk storage capability is ground mounted, the division POL point is not mobile and is very vulnerable to a wide range of enemy weapons. For these reasons, it is located to the rear of the division area to preclude small movements in the line of contact from dictating a relocation due to increased risk. The division POL point is resupplied in turn by the corps.

The ammunition system is more complex and none of the ammunition supply facilities are organic to the division. As the Army is organized today, the trucks of the support platoon would have to drive back to a corps ammunition

supply point (ASP) located in the vicinity of the division rear. An ASP is a large non-mobile supply point operated by a corps ammunition company. All the stocks of an ASP are stored on the ground. Doctrinally, one ASP is normally considered to support a division and is expected to have enough ammunition on hand for three to five days of support to the division.

In an effort to streamline the ammunition process, emerging doctrine calls for the establishment of three or four ammunition transfer points (ATP) within the division. Assets for the ATP's will be organic to DISCOM and one ATP will normally be assigned to support each committed brigade of the division. The ATP is composed of forklifts and cranes to transfer ammunition from corps linehaul trucks to the battalion ammunition trucks of the support platoons. Only a limited choice of high volume critical munitions, such as tank main gun, anti-tank missile and 155 mm artillery will be available at the ATP. The ATP is mobile and is completely dependent on the timely and frequent arrival of convoys from the corps ammunition storage areas (CSA) if it is to be able to fulfill its mission. In order to draw munitions not supplied by the ATP, or when the ATP has no munitions, support platoon trucks will be required to travel to the ASP.

Figure 1 illustrates the support structure of two brigades down to the company level. In figure 1, Companies A and B reflect two possible methods of supply. At A Company the resupply action does not deliver resources directly to

the company, but rather caches, i.e., prestocks them at an alternate battle position. Conversely at B Company's position, the fuel and ammunition are delivered directly to the unit location. Notice that if the support platoon vehicles only have to travel to the brigade support area (BSA), the trip is considerably shorter than if vehicles are required to go to the ASP or the DISCOM POL point. Additionally corps transportation assets are used to move munitions forward to the ASP and ATP; while DISCOM assets move POL forward to the brigade POL point.

The past several paragraphs have outlined the resupply process. The logical decision structure for this process is presented in the bulk of this thesis. Before presenting the resupply logic, three specific areas remain to be discussed. These areas are: the STAR combat model, SIMSCRIPT II.5 and the Software Design and Documentation Language (SDDL).

B. OVERVIEW OF SIMSCRIPT AND STAR

As stated earlier the purpose of this thesis is to expand the current brigade STAR model to portray selected BLUE logistics functions as an integral part of the combat process. To understand the design of the logistics module, a basic understanding of the STAR combat methodology and capabilities is required. STAR is written in SIMSCRIPT II.5, a language which was designed specifically for discrete event simulations. As a result, SIMSCRIPT handles many of the bookkeeping tasks such as managing queues,

keeping track of simulated time and managing arrays. Additionally the code is extremely readable.

SIMSCRIPT is based on the concepts of entities, attributes and sets. Entities are equivalent to elements or physical things. STAR uses entities to represent weapons systems such as tanks or anti-tank missile launchers. In the logistics module, ammunition and fuel trucks would be entities.

Attributes represent characteristics or status of entities. Attributes may be used to differentiate between entities or to indicate if an entity is alive or dead. Other examples of attributes could be vehicle speed, weapon range or vehicle dimensions. The logistics module will use attributes such as vehicle load capacity, the number of galons of a fuel type on hand, or the number of tank rounds in the ATP.

Another very useful feature of SIMSCIPT is the concept of sets. Sets are groupings of entities. As the language is written, only entities may belong to sets. A set may be established to contain the members of a specific tank company and thus sets may be used to represent military units. A specific application in the logistics module is to place all the resupply trucks going to a specific company in a set called a convoy.

The basic STAR model consists of a direct fire ground model with artillery and air/air defense modules. It simulates terrain, target detection/selection, damage assessment

and movement. It is capable of portraying a BLUE brigade opposing a RED division.

The integration of the ammunition and fuel resupply processes into STAR will utilize many of the existing routines.

The simulated terrain can portray any area desired by the user. The terrain is derived from map data of the area selected by the user. Because the terrain model depicts actual geographical features, the supply routes can be plotted on the existing roads. The terrain model also allows for the realistic placement of the supply facilities to provide for cover, concealment and accessibility.

The movement routines will allow for the movement of resupply vehicles over preselected routes as a function of terrain and the vehicles' mobility attributes (i.e., accelerations, limiting speed, etc.).

The target detection/selection routines will permit resupply vehicles to be detected and selected as targets by RED combat vehicles, aircraft and artillery. Detection is a function of line of sight, range, target exposure, and yields a time to detect. Selection is a function of range and target priority.

The damage assessment routines determine if the resupply vehicle was hit and, if hit, how much damage was caused.

The suppression module will be used to determine the proximity and density of hostile fire as a basis for making decisions about terminating resupply actions and moving resupply vehicles.

C. USE OF SDDL IN PROGRAM DESIGN

The logistics module was written using Software Design and Documentation Language (SDDL). SDDL is a word processor created specifically for the design and documentation of structured programs [Ref. 12]. This approach was chosen over traditional flowcharting because it provides a readable description of the program logic in a structure closely resembling actual program format. This was possible because the SDDL syntax uses keywords to invoke design structures. The design structures consist of modules which can be defined to be programs, events, routines, etc.; and block designators which can be defined to be control statements such as IF, ELSE, ENDIF or DO. Module invocation keywords can be defined to be CALL, SCHEDULE or PERFORM. Indentation is used to indicate the operational order of the IF and DO statements within each code module. Structure exits and routine invocations are accentuated by arrows. In addition to displaying the structures of each code module, SDDL will provide diagnostic statements whenever substructure errors are detected. For example, if a DO LOOP is not terminated, the output will show an error statement. A feature of SDDL that is of particular benefit to the designer of programs with numerous routines is the summary information that is provided. The summary of information provides a table of contents, a module reference tree, and a module cross reference listing. The table of contents lists the page

number for each module and summary listing. The module reference tree presents the modules in the order called within the program; while the module cross reference listing enumerates the locations where each module is called. Additional cross reference listings are available by marking selected words, titles, phrases or variable names. The many features and felxibility of SDDL allowed the logistics module to be designed and documented concurrently while providing an effective guide for future programming.

III. DETAILED EXPLANATION OF THE LOGISTICS MODULE

A. INTRODUCTION

This chapter contains a detailed description of the proposed logistics module. Each routine and event is discussed in an attempt to document the simplifying assumptions and the reasons for selecting a specific methodology. Figure 2 shows a flowchart of the events and routines presented in Appendix A. A brief description of the events and routines is given in the next section and a detailed discussion of each event and routine makes up the remainder of the chapter.

B. BRIEF DESCRIPTION

Event RS_EVALUATE assigns each combat vehicle a level of need (L.O.N.) based on the ammunition and fuel used.

Routine RS_BATTALION_LOGIC determines within each battalion the order in which each company should be resupplied based on L.O.N., supply status and the selected resupply tactic.

Routine RS_ALLOCATE allocates ammunition and fuel assets to the company being considered based on availability and the efficient utilization of transportation.

Routine RS_UPDATE is called by RS_ALLOCATE for a specific ammunition/fuel type. It transfers trucks and stocks from the trains to the convoy being formed for the company.

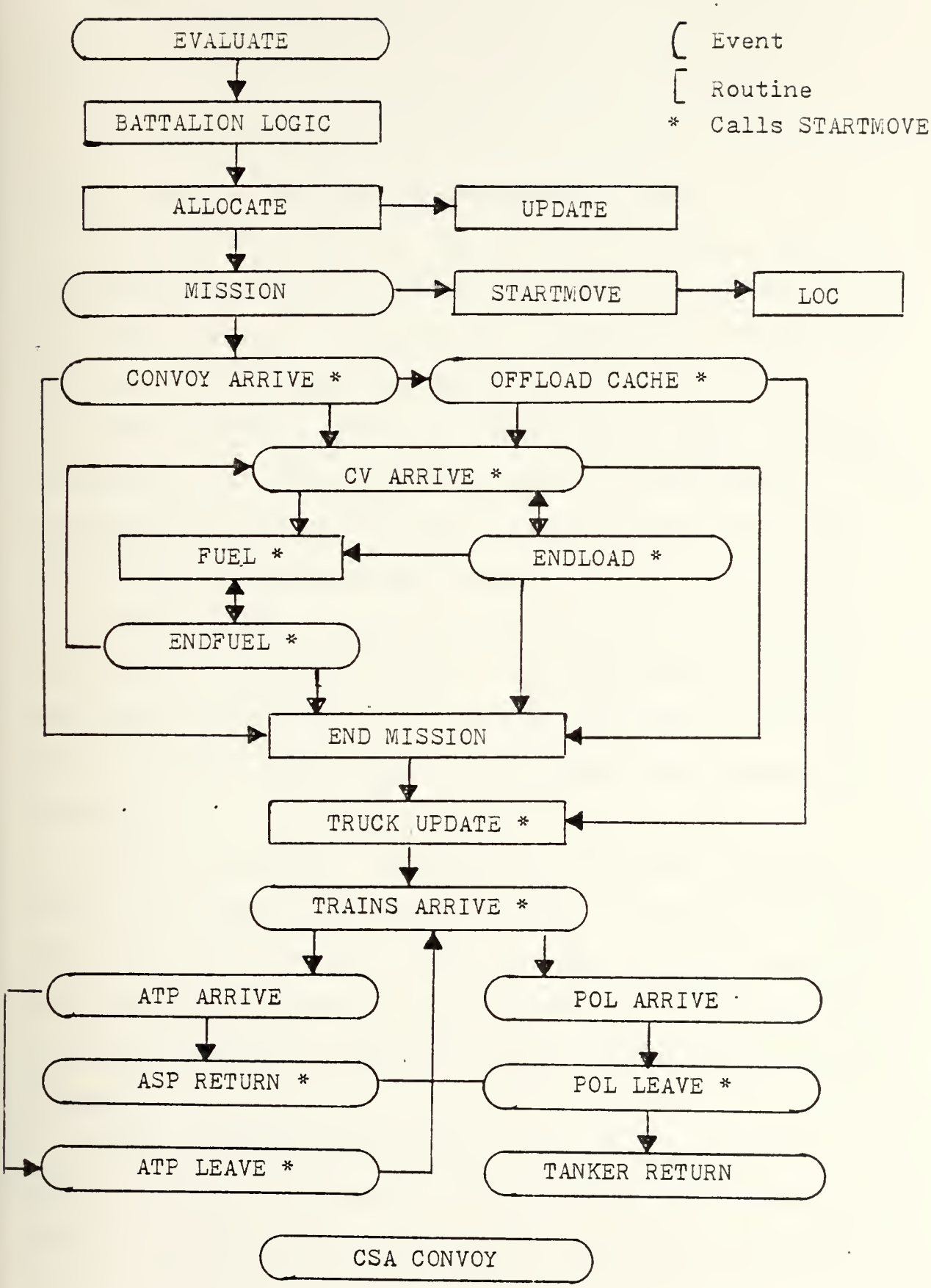


Figure 2 Flowchart of Events and Routines

Event RS_MISSION is scheduled by RS_ALLOCATE for each convoy in a user input time lag that simulates the time required to process a request and assemble a convoy.

Routine RS_START_MOVE is called whenever a vehicle or convoy needs to be moved on the terrain model.

Routine LOC is part of the STAR ground combat model and is a primary interface between the logistical process and the combat process. It moves all vehicles from their start positions to their destination.

Event RS_CONVOY_ARRIVE is scheduled for each convoy and determines when the convoy has reached its destination. Depending on the resupply tactic, it then starts to build a "cache" or to resupply the company.

Event RS_OFFLOAD_CACHE is scheduled for a convoy when the resupply tactic is "cache." It completes the "cache" and starts moving the convoy back to the battalion trains area. If the company is at this location its resupply is started.

Event RS_CV_ARRIVE is scheduled for combat vehicles which need a specific ammunition type. It determines when the combat vehicles have arrived at their destination (battle position or company resupply area). If the location is the company resupply area, it starts rearming/refueling the company.

Event RS_ENDLOAD is scheduled for a combat vehicle. Upon completion of rearming, it starts the refueling process for the current vehicle and calls a like combat vehicle to

move to the company resupply area. It checks for the completion of the mission.

Routine RS_FUEL is called for a vehicle needing a specific fuel type. If a refuel point is idle, the vehicle starts refueling otherwise the vehicle is placed in a queue.

Event RS_END_FUEL is scheduled for a combat vehicle. It completes the refueling process and moves the combat vehicle back to its battle position. If another combat vehicle is waiting in the queue for this fuel type, the event will start the refuel process for it. Event RS_END_FUEL checks for the completion of the mission.

Routine RS_END_MISSION is called whenever a resupply mission has been terminated and is used to indicate that the company supply status has changed.

Routine RS_TRUCK_UPDATE is called for convoy/cache trucks to adjust the amount of ammunition/fuel on each truck prior to their move back to the battalion trains area.

Event RS_TRAINS_ARRIVE is scheduled for all convoy/trucks returning to the battalion trains area. It consolidates the ammunition/fuel left on the trucks returning from a resupply mission to the smallest number of trucks. Based on a user input threshold of partial loads, this event sends trucks to the ATP or brigade POL point for replenishment. For trucks returning from the ATP, ASP, or POL point it adds the truck to the battalion trains.

Event RS_ATP_ARRIVE is scheduled for every battalion ammunition truck sent to the ATP. If the ATP is too busy or in a stockout position for the ammunition type needed, it

sends the truck to the ASP. If the truck remains at the ATP, the event starts the reload process or has the truck wait in a queue.

Event RS_ATP_LEAVE is scheduled for every battalion ammunition truck reloaded at the ATP. It completes the reload process and sends the truck back to the battalion trains area. It continues the reload process for any trucks waiting in the queue for the same ammunition type.

Event RS_ASP_RETURN is scheduled for all battalion ammunition trucks sent to the ASP. It accounts for the time it would take for a truck to make a round trip from the ATP to the ASP. It then sends the truck back to the battalion trains area.

Event RS_POL_ARRIVE is scheduled for every battalion fuel truck sent to the brigade POL point. When the truck arrives, the event starts the refill process or has the truck wait in a queue for that fuel type.

Event RS_POL_LEAVE is scheduled for every battalion fuel truck refueled at the brigade POL point. It completes the refill process and sends the truck back to the battalion trains area. If a POL point tanker has been emptied, it schedules RS_TANKER_RETURN.

Event RS_TANKER_RETURN is scheduled for all empty DISCOM POL tankers at the brigade POL point to account for the time it would take to make a round trip to the DISCOM POL point.

Event RS_CSA_CONVOY is scheduled periodically to simulate the arrival of corps ammunition convoys at the ATP.

C. EVENT RS_EVALUATE

The first portion of the STAR resupply model is called RS_EVALUATE. The purpose of the routine is to evaluate the fuel and ammunition status of the vehicles, crew served weapons, platoons, and companies as portrayed in the model. The SDDL code section imitates the logical process of each vehicle commander periodically taking stock of his level of need (L.O.N.) for ammunition and fuel. If necessary, the vehicle commander passes his L.O.N. information to the platoon leader. The platoon leader in turn evaluates the L.O.N. of his platoon and, if necessary, informs the company commander of the platoon's L.O.N.. The company commander determines the L.O.N. of the company based on the aggregate status of his platoons. Having determined the company L.O.N., the commander then passes his supply request to the battalion headquarters for action. For modeling this process it is necessary to have a quantitive measure for defining/determining the L.O.N. of company members and companies. The term level of need (L.O.N.) is a subjective descriptor of the goodness or badness of resources (fuel and ammunition) and must imply a sense of urgency or priority. While this may sound like an awkward concept, it is in fact, representative of real life situations ranging from - "gee, it would be nice to top off now" to "if we don't get more ammo, we will be out in 15 minutes."

In order to convey the information described above, the level of need (L.O.N.) concept was used. The levels are separated into four categories: full (F), want (W), approaching critical (AC), and critical (C). The levels of need are defined as follows:

1. "Full" (F) - The vehicle or unit is at 100 percent of stowed load/fuel capacity or so close to 100 percent that it will not request resupply action.

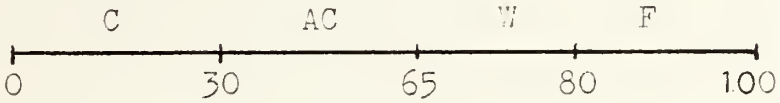
2. "Want" (W) - The vehicle or unit is not at "full" stowed load status, but is not in such a position where potential mission accomplishment is jeopardized. The "want" level will initiate a resupply request, but at the lowest priority.

3. "Approaching Critical" (AC) - This level is meant to imply that the supply status reduces the mission potential of a vehicle or unit. "Approaching critical" status initiates a resupply request of higher priority than the "want" level.

4. "Critical" (C) - The stowed load of the vehicle/unit is at a level such that the survival of the entity or its mission accomplishment is immediately threatened by a lack of resources.

For individual vehicles or systems, the L.O.N. thresholds are user input percentages of the amount of fuel/ammunition remaining. Figure 3 represents the thresholds used in constructing the column in Table I for determining the fuel L.O.N. for a tank. Any tank with less than 30% of

its fuel remaining would be considered "critical." If the fuel remaining was greater than or equal to 65% but less than 80%, the tank would be considered "want." The threshold values for each weapon system are model inputs determined by the user.



Figue 3 L.C.N. Intervals

TABLE I VEHICLE L.C.N.

VEHICLE	TANK		IFV		CFV		ITV	
L.O.N.	AMMO	FUEL	AMMO	FUEL	AMMO	FUEL	AMMO	FUEL
C	30	25	50	50	65	50	45	50
AC	65	50	70	70	75	75	60	75
W	80	90	90	85	95	83	85	82
F	100	100	100	100	100	100	100	100

In the model, once the type vehicle has been determined, the percentage of ammunition remaining is calculated and a table is searched for the appropriate L.O.N. which is then assigned to the vehicle (See Table I). For example, if a tank has 26 rounds remaining (26/40 = 65 percent), the L.O.N. is W. Next, the percentage of fuel remaining is calculated and the table is again searched for an L.O.N. For a tank with 182 gallons remaining, (182/508 = 36 percent) the L.O.N. would be (AC). Once the second L.O.N. is

calculated, it is compared with the first and the worse of the two L.O.N.'s is assigned to the vehicle. Thus a tank with 26 rounds and 182 gallons remaining has an L.O.N. of AC.

As each vehicle L.O.N. is updated, the number of rounds expended by type is accumulated as a platoon and company attribute. This identical process is completed concurrently for fuel.

The model will determine a platoon L.O.N. for each type of platoon by entering the appropriate table (See Table II) with the number of platoon members alive and the cumulative distribution of their L.O.N.'s.

TABLE II PLATOON L.O.N.

PLATOON L.O.N.		NUMBER OF VEHICLES ALIVE					
		0	1	2	3	4	5
C	No. C	0	1	1	2	2	3
AC	No. AC+C	0	1	1	2	2	3
W	No. W+AC+C	0	1	1	2	3	4
F	No. F+W+AC+C	0	1	2	3	4	5

A platoon with four (4) XM-1's alive would be "critical" if two or more tanks were "critical." If this condition is not met, the platoon would be "approaching critical" if the total number of C and AC tanks is greater than or equal to two (2). For the platoon to be classified as "want," the conditions for "critical" and "approaching critical" must not be satisfied and the sum of the C, AC and W vehicles

must be greater than or equal to three (3). The numbers used to fill out the tables are user input and may vary for each type of platoon.

The process of developing a company L.O.N. is similar to the platoon method. An aggregation of the platoon L.O.N.'s is used to determine the company L.O.N. The major area of concern for the company L.O.N. is whether or not the platoon organization is homogeneous. If all the platoons are tank or mechanized infantry (INF(M)), the user need only designate his priorities as in Table III. However, if the company is organized as a company team, the user must decide to either accept a homogeneity assumption for supply or designate a table of combinations for the team L.O.N.

TABLE III COMPANY L.O.N.

COMPANY L.O.N.		NUMBER OF PLATOONS ALIVE					
		0	1	2	3	4	5
C	No. C	0	1	1	1	2	2
AC	No. AC+C	0	1	1	1	2	3
W	No. W+AC+C	0	1	1	2	3	4
F	No. F+W+AC+C	0	1	2	2	4	5

The use of a company team L.O.N. table may be required because of differences in the stowed load capabilities of various weapons systems. For example, the infantry fighting vehicle has a stowed load of seven (7) TOW missiles compared to 55 rounds of 105 mm maingun ammunition for an

XM-1 tank. Table IV gives an example of L.O.N. categories for a company team composed of two tank and two mechanized infantry platoons. This team would be "critical" if one or more infantry (M) platoons are "critical" or two or more tank platoons are "critical." The team will be "approaching critical" if one or more infantry (M) platoons are AC or the sum of the C and AC tank platoons is greater than or equal to two (2). For a team to be "want," the sum of the A, AC and W platoons must be greater than or equal to three (3) while the conditions for C and AC are not satisfied.

TABLE IV COMPANY TEAM L.O.N. (2 Inf (M) & 2 Tank)

TEAM L.O.N.	PLATOON STATUS			
		INF (M)	TANK	INF+TANK
C	C	1	2	2
AC	C+AC	1	2	2
W	C+AC+W			3
F	C+AC+W+F			4

As the L.O.N. of each company is determined, RS_EVALUATE will check to see if the company should be considered for resupply. The company will be considered under two possible conditions: if a company is "critical" or if the company does not have a supply mission enroute.

D. RS_BATTALION_LOGIC

Routine RS_BATTALION_LOGIC simulates the battalion commander's thought process wherein he decides which companies should be resupplied and which companies can be resupplied. This decision process is a combination of many inputs which have been reduced to the following:

1. The method of resupply chosen (cache or on position).

2. The urgency of the requesting unit as portrayed by L.O.N.

3. The tactical situation of the company portrayed by the suppression index.

4. The assets available to the commander. The allocation of assets is expanded in event RS_ALLOCATE.

From event RS_EVALUATE, the battalion commander has a list of his companies with their L.O.N. category and resource requirements. He takes this list and continues the prioritization using the second and third items as numbered above.

Before the routine can imitate this thought process, it is necessary to input the method of supply for each company. The user is limited to two (2) methods, "cache" or "unit location." The "cache" method entails sending resupply vehicles forward to some specified position, unloading the resources and returning to the battalion trains. At some time in the future, the company will move to this position. Within the model, the convention will be to always pick

some succeeding battle position as the "cache" site. This method maximizes the use of ammunition supply assets by enabling constant utilization of the ammunition trucks. There is, however, a problem in caching fuel. In order to include fuel, the support platoon would have to either deposit 55 gallon drums and/or bladders (100 or 500 gallon) or leave fuel vehicles at the "cache" site. In reviewing present and proposed unit organizations [Refs. 5, 6, 7, 8], manuals [Refs. 2, 3, 4] and discussions with other active duty officers, it was determined that the option of leaving drums or bladders should not be included, at least initially. Realistically, the drum/bladder cache is not infeasible, but it requires more assets than are currently available (i.e., a cargo truck to haul and pumps to transfer). The problem associated with leaving fuel trucks at a cache site is twofold. First, leaving the trucks at the cache site puts them stationary and well forward of the battalion trains with a greater probability of detection and engagement. Secondly, leaving the trucks at the cache site essentially takes those trucks out of service until the company comes back to that position and refuels. As ground combat occurs in reality, there is no method to determine how long fuel trucks might be expected to sit at a "cache" site. For these reasons, routine RS_BATTALION_LOGIC will only "cache" fuel when the requesting company is "critical." The "cache" method used for fuel will be to leave fuel trucks at the "cache" location.

At this point, there may be some confusion as to who picks the method of supply discussed in routine RS_BATTALION_LOGIC. Communications among the various battalion elements would normally decide the "how to do it" (i.e., method) either by standard operating procedure (SOP), battalion commander's direction, etc. However, within this routine, the method of resupply is necessarily a user input. The method would be carried as an attribute of each company for model accounting purposes. As currently planned, the method of supply attribute can not be changed as the simulation progresses, but such a change is considered feasible in a future revision.

The "unit location" method of supply is best described in the generally accepted term of unit distribution. The required resources are delivered directly to the unit's general location while the unit is there. Then, the transfer process takes place by having unit and logistical vehicles park next to each other while resources are transferred manually or mechanically. The "unit location" method minimizes the time that the combat unit must spend in resupply activities because the resources do not have to be picked up from the ground. There are also more people available to assist the resupply, (i.e., crews from the resupply vehicles).

As previously described, the RS_EVALUATE event creates a priority ordered list of supply requests for each battalion. The next consideration is how a battalion commander further prioritizes a request when there is more than one company in

any one L.O.N. category. Normally, the commander would make some subjective decisions. The possible criteria for tie breaking are as many and varied as commanders and tactical situations. For this routine, three possible criteria were considered.

1. The importance of the unit as regards to key terrain and assumed enemy objectives.

2. The ability of the unit to bring combat power into the battle.

3. The resource status of the unit as regards to its ability to fight and survive as a unit.

Case one is a user determined priority; in case of a tie between A Company and B Company, priority goes to A Company. Case two would break ties in favor of the unit with the greatest number of weapons systems alive. This assumes that bigger is better and larger units would have more combat power. Case three breaks ties in favor of the unit with the smallest number alive. This case is premised on keeping a maneuver unit supplied to prevent, where possible, degradation of the unit due to lack of resources. There is an implicit assumption that to fight and survive, a smaller unit must fire more rounds per system than a like unit with more systems available. The criteria chosen for the model was case two, the greatest number of weapons systems alive.

As part of his mental appraisal of the situation, the battalion commander must decide how much risk he is willing to accept in committing his resupply assets. In actual

combat, this process has many inputs ranging from the number of trucks on hand to the pitch of the company commander's voice on the radio. To model the degree of risk, it is necessary to have some methodology for measuring the intensity of combat. Within the STAR combat model, there is a suppression module that can be used to implement the risk concept. The module is explained in[Ref. 13]. The appropriate pages from [Ref. 13] are included in Appendix B and should be read before proceeding with this chapter. The suppression module is used because it has already been written into the main model. The use of the suppression methodology requires that the resupply model include all the assumptions and constraints of the suppression routine when and if it is used. Using the terminology and notation of Appendix B, the following example is offered:

1. The battalion commander's user input value of a go/no go value for R is 5.

2. The resupply vehicles (trucks) have a suppression susceptability of 10.

3. The example values of r and d from Annex B are used.

4. The company receives a 152 mm artillery preparation as follows:

TABLE V Suppression Index Example

	1st Plt.	2nd Plt.	3rd Plt.	4th Plt.
r 1	2	2	0	1
r 2	3	4	0	1
r 3	2	1	0	0
r 4	1	0	0	0
R=	5.115	5.46	0	1.95

Averaged over the four platoons in the company, R is 3.13, which is below the abort mission threshold of five (5); therefore, the mission would go. The implementation of the risk methodology will require close coordination with the user and some amount of experimentation to find values of R that equate to subjective risk of the combat arms user.

Using the suppression methodology to determine the risk allows the user to view risk as an essentially continuous variable. This provides a degree of flexibility in that the value of the abort mission threshold can be set low for low risk or high for accepting a higher risk. This methodology is used again at the point where the combat vehicles are loaded and can be expanded to show uses for a time delay factor as discussed in chapter IV.

When a "cache" is requested, the area suppression index is considered to be zero.

The last criteria to be explained is "supply status." The "supply status" is a company attribute that equates to the number of previously scheduled supply missions that have not yet been completed or terminated. The attribute is increased each time a mission is scheduled for the requesting company. The attribute is decreased by one after a mission is successfully executed or otherwise terminated.

Having explained the background and terminology of the routine RS_BATTALION_LOGIC, it is appropriate to discuss the SDDL code on page 2 of Appendix A. The first two if statements in the routine remove any company that is within the full range or that is non-critical with a supply mission enroute. The list of units eligible for resupply is now reduced to "critical" units or other less than critical units that have no supply actions currently scheduled. Next, if the method to be used is "cache," the logic calls directly to the allocate routine because there is no consideration of risk. If there is a risk criteria, the routine checks for the go/no go value and calls routine RS_ALLOCATE if the logic is a go.

E. RS_ALLOCATE

The routine RS_ALLOCATE is a logical continuation of the battalion commander's thought process from the preceding routine, RS_BATTALION_LOGIC. The review process of the battalion logic routine is complete for one unit and an attempt is now made to match assets available with the missions to be executed. For simplicity and feasibility of

this routine, several factors have been eliminated. A primary example of this is the decision not to cross level ammunition stocks on the support platoon trucks. This simplifying assumption removes the parameters of available manpower and the ability of a man to transfer boxes from one truck to another. Currently, this routine only considers tank main gun rounds and TOW missiles. Although this only allows the logistical model to supply major calibers, the degree of resolution and workload are adequate for simulation of the resupply process. A further simplifying assumption is that all loads of fuel and ammunition are homogeneous. It is realized that this is not a totally realistic representation of the supply process, but this prevents the accounting and record keeping steps in the model from becoming prohibitive. The last major simplification step was the total omission of resupply logic for indirect fire weapons. The reason for this was the author's allowable time limits. However, this same logic will have a general application to the supply of indirect fire units and the organic fire support elements of the maneuver battalions.

Within the allocate routine, there are several major decision thresholds that may be set by the user to mimic the battalion thought and allocation process. These values are input as a percentages and establish thresholds for various allocation functions. It is necessary to discuss the analysis motivating the choice of this methodology.

The routine begins by applying the "cache" fuel logic. As discussed previously, unless the company L.O.N. is "critical," no fuel trucks will be sent to the cache site. The next decision that needs to be made is: given that the battalion is still receiving requests for resupply and some materials have already been dispatched to that unit, what more should be sent to the reqisitioner? If the unit L.O.N. is not critical and a resupply mission has been sent, take no action until that mission is terminated.

When a unit is "critical," each time a request is received the model will attempt to allocate the amount requested minus the amount already alloted. In reality, there is some point at which the battalion commander may want to say "all right, that company has been allocated what I consider a sufficient amount." To allow for this thought process to be modeled, a user input threshold is required. For example, if a "critical" company has been allocated 75% of its total requirements, it is temporarily removed from the allocation process. This methodology applies only to "critical" units and prevents the allocation logic from passing a user input point of diminishing return.

So far in the allocation process, only the total amount of rounds or gallons requested by the company has been addressed. It is also necessary to have a method for apportioning the basic load vehicles that carry the fuel and ammunition. Once the status of the battalion's stocks has been determined and the material allocations made, the transportation resources are reviewed and parcelled out.

As before, the emphasis is on the "critical" units. If there are none, so much the better. If there is only one, then that unit is allocated whatever is necessary. In the case of multiple critical units, some trucks are reserved for the other critical companies. This allotment prevents one critical unit from receiving all the available assets at the expense of other critical units. When the units are non-critical the L.O.N. priorities and tiebreaking rules described in routine RS_BATTALION_LOGIC still apply. One final decision threshold remains to be discussed: the breakpoint for sending partial loads. The assumptions of this routine prevent overloading and mixing of truckloads, which may result in requiring three trucks to move 2.1 truckloads. This is a plausible requirement in any real situation and requires a model algorithm to simulate a human decision maker. The method adopted is again a user input percentage for each specified L.O.N. The user may decide never to dispatch a truck if only ten percent of the fuel or ammunition on board is required. (This is a variable level set by the user). All the trucks allocated to a company by routine RS_ALLOCATE form a convoy. The allocation process may form a convoy consisting of only one truck.

The past several paragraphs have discussed a number of decisiom thresholds for allocating resupply assets of the battalion to support the combat arms company. This series of resupply on/off switches is not designed as a way to constrain resupply; rather, to provide a flexible methodology for assessing the impact of the threshold levels.

F. ROUTINE RS_UPDATE

Routine RS_UPDATE is called by RS_ALLOCATE for a specific ammunition/fuel type. It transfers trucks and stocks from the trains to the convoy being formed for the company.

G. EVENT RS_MISSION

This event calls the RS_START_MOVE routine to begin the simulated movement of resupply vehicles. Event RS_ALLOCATE schedules an RS_MISSION for each convoy departing the battalion trains enroute to a company resupply area. The time lag for scheduling an RS_MISSION is a user input that simulates the time required to organize a convoy. The event RS_CONVOY_ARRIVE is also scheduled to determine when and if the resupply convoy arrives at its mission location.

H. ROUTINES RS_START_MOVE AND LOC

Routine RS_START_MOVE is used to set the location attributes of each resupply vehicle to the present location and the location to which the truck is going. RS_START_MOVE also calls routine LOC of the present STAR Combat model. Routine LOC checks the alive or dead status of the vehicle, and, if appropriate, calls routine move of the main STAR movement module. The RS_START_MOVE and LOC routines are a primary interface of the resupply module and the existing STAR air/ground combat model.

I. EVENT RS_CONVOY_ARRIVE

Event RS_CONVOY_ARRIVE is used to monitor the arrival of a resupply convoy at a company resupply area. Once the model detects the arrival of a convoy, the suppression methodology is used to determine the suppression index. The suppression index is compared to a user input called abort mission threshold. The threshold is a value above which the commander does not wish to accept the risk of enemy action. For values above the threshold, the convoy returns to the battalion trains; this is accomplished by calling routine RS_END_MISSION, which is described later in this chapter.

For cases where the mission is not aborted, the routine determines what method of supply was designated for this company and simulates the convoy commander's checking to see if any vehicles were lost enroute. Total resources available in the convoy are then adjusted for losses. The implementation of the supply methods begins in this routine. For the "cache" method, a time to unload pallets onto the ground must be determined. At present, the authors assume that no manpower would be available for this and field expedient techniques must be used. A possible technique used in this case is to remove the tie downs, move the vehicle rapidly in reverse and then brake hard, causing the pallets to fall off by their own momentum. The RS_OFFLOAD_CACHE event is scheduled after a user input time delay to simulate the unloading process.

When the "unit location" method is used, the routine simulates the convoy commander reporting the number/type of rounds/gallons and the number of trucks in his convoy to the unit commander. The unit commander, in turn, instructs his unit to move, two at a time, to each resupply vehicle. The unit combat vehicles move by order of L.O.N. This movement can take place while the company is engaged in a direct fire battle as long as the abort mission threshold of the resupply convoy is not exceeded. The assignment of two combat vehicles per resupply vehicle was chosen for various reasons. Removing one or more platoons for resupply could have disastrous results on the combat capability of the unit. There are three ways to address this problem: don't remove a platoon, remove a platoon regardless of the combat situation or implement additional combat movement decision logic to decide when a platoon could or could not resupply as a unit. After analyzing these alternatives, it was determined that the simplest approach was to resupply by vehicles rather than by platoons. If only one vehicle at a time were to be dispatched to each truck, the potential for unrealistically long resupply times is very great. Two combat vehicles per resupply vehicle is a good choice in that one combat vehicle can be positioned on each side of the resupply vehicle (fuel or ammunition). Although this is a severely cramped working space for ammunition unloading, it is common field practice. For the fuel truck, one or two combat vehicles per truck are used, depending on the pump and hose equipment available.

It is necessary to point out that the movement by L.O.N. could remove all the vehicles of one platoon or from a geographic area of the company battle position to the company resupply area. This is a pertinent area for future enrichment of the model. Also included in this event are several fuel/ammunition attribute accounting adjustments and schedulings of other events. The two most important events scheduled by RS_CONVOY_ARRIVE are the events RS_OFFLOAD_CACHE and RS_CV_ARRIVE. These events are presented in the order mentioned for logical explanation of the mission sequence.

J. EVENT RS_OFFLOAD_CACHE

Scheduling of the RS_OFFLOAD_CACHE event occurs only when the cache method of supply is chosen. This event performs all the accounting associated with placing piles of ammunition on the ground in the company supply area. If fuel is included, the appropriate number of trucks are deleted from the convoy and they remain at the cache site.

If the requesting unit is already present at the resupply area, the cache unloading method is still used and the combat vehicles are scheduled at the ammunition piles by event RS_CV_ARRIVE. Other events and routines are used to move the convoy back to the battalion trains.

K. EVENT RS_CV_ARRIVE

Event RS_CV_ARRIVE is primarily designed to determine if combat vehicles have arrived at the resupply area, check for "cache," simulate the individual vehicle resupply actions

for ammunition and perform the associated model accounting procedures. After checking the area suppression index, the resupply process is started by calculating the rearm time for each combat vehicle present. The attributes for the combat vehicles' stowed load are increased as the resupply trucks' amount on hand attribute is decreased. The event RS_ENDLOAD is scheduled for each combat vehicle in the amount of time it takes to rearm that vehicle. This logic applies, regardless of the method of supply. Within this routine, the only major difference between "cache" and "unit location" is the time differential caused by having to pick rounds up from the ground as opposed to loading from truck bed height. As the vehicles are rearmed, counters are increased to insure that only the actual amount on hand is loaded, no stowed load capacity is exceeded and the number of vehicles rearmed by ammunition type is recorded.

The refuel process may be initiated from this event by calling routine RS_FUEL. RS_FUEL may still be called, even when all ammunition actions are complete. Finally, RS_CV_ARRIVE is scheduled for each vehicle to be rearmed and/or refueled.

L. EVENT RS_ENDLOAD

The completion of the ammunition reloading of a vehicle is simulated by this event. The model assumes that combat vehicles will be rearmed before refueling. This is a simplifying assumption built into this event. There is no explicit queue for vehicles requiring ammunition upload because

the endload event only schedules vehicles to ammunition trucks on a one for one replacement basis. Once a vehicle has been rearmed, it is passed to the RS_FUEL routine for refueling. If there is no ammunition remaining or no further requirements for ammunition, this event, in conjunction with RS_CV_ARRIVE, will continue to call vehicles to the resupply area if they need refueling. This process is described next in routine RS_FUEL and event RS_END_FUEL.

For a resupply mission to be completed, there are various combinations of two basic conditions that must be satisfied. These conditions are the exhaustion of an ammunition/fuel type or the satisfaction of all requirements for an ammunition/fuel type. In order to confirm mission completion, a system of counters is used in this event and in event RS_END_FUEL. Each vehicle arriving at the resupply area has its L.O.N. set to "full" by this event. Setting the vehicle L.O.N. to "full" is part of the process that monitors completion. As the event loops through each ammunition and fuel type, it adds one to the "loop counter" and checks for the conditions mentioned above. For each ammunition and fuel type, if the number of vehicles alive equals the number of vehicles "full," one is added to the "mission counter." One is also added to the "mission counter" if the ammunition or fuel type is exhausted. When the "mission counter" equals the "loop counter" the mission is considered complete and RS_END_MISSION is called to terminate the resupply.

M. ROUTINE RS_FUEL

This routine is scheduled for one vehicle requiring one type of fuel. As discussed previously, all vehicles will eventually be routed to the fuel trucks. Since the arrival rate for fueling is uncontrolled, the fueling routine establishes a first in, first out (FIFO) queue for each type of fuel. The number of fuel service points is determined by the capabilities of the specific fuel trucks organic to the battalion support platoon of the unit now being resupplied. Within this routine, a refuel time is calculated for each vehicle and the appropriate attributes are updated. With the exception of the FIFO queue, this routine is almost an exact duplicate of the RS_CV_ARRIVE event. The duplication is intentional in that refueling and rearming are very similar from the simulation point of view. Event RS_END_FUEL is scheduled for this combat vehicle in the amount of time required to refuel the vehicle.

N. EVENT RS_END_FUEL

After the time to refill a combat vehicle has elapsed, this event sets the appropriate counters for the number of vehicles refueled and then calls the next vehicle from the queue. The same double check mechanism for not excluding any vehicle from rearm/refuel is used here as it was used in the preceding modules for fuel and ammunition. Additionally, RS_END_FUEL repeats the "mission" and "loop counter" logic, already described in RS_ENDLOAD.

O. ROUTINE RS_END_MISSION

Four other events or routines may schedule the RS_END_MISSION event. Although there are many possible schedulers, there are only two basic causes for scheduling this event. The first cause is exceeding the abort mission threshold. This means that the resupply area is receiving enemy fire in sufficient quantities to cancel the ongoing resupply. RS_CONVOY_ARRIVE, RS_CV_ARRIVE and RS_ENDLOAD all check the suppression index and can schedule RS_END_MISSION due to hostile fire. The second possible cause for mission termination is the completion of resupply. As explained in the preceeding events, partial mission completion signals are set and summed to an end of mission counter in RS_ENDLOAD and RS_END_FUEL. Event RS_END_MISSION deletes one from the company supply status attribute defined in RS_MISSION. Deleting one from the supply status is, in effect, simulating the communication of resupply mission termination to the battalion headquarters of the company being resupplied. This is particularly important for non-critical units, which the logic prevents from having more than one resupply mission enroute at a time. RS_END_MISSION also calls the RS_TRUCK_UPDATE routine.

P. ROUTINE RS_TRUCK_UPDATE

There are two primary functions of the RS_TRUCK_UPDATE routine. First, the ammunition/fuel remaining in the convoy at mission termination is distributed uniformly within the convoy; secondly, the convoy movement process is begun.

The distribution of the remaining resources was implemented on the following premise. During a resupply mission, it is assumed that the trucks have been unloaded at a constant rate. Therefore, when the mission is terminated the amount of ammunition/fuel remaining will be uniformly distributed by type over the trucks in the convoy. This is necessary because individual trucks are not portrayed during the unloading process.

After the loads are distributed over the vehicles, routine RS_START_MOVE is called to begin the movement of the convoy back to the trains and Event RS_TRAINS_ARRIVE is scheduled for this convoy.

Q. EVENT RS_TRAINS_ARRIVE

When the convoy returns to the trains, each ammunition and fuel type in the convoy is summed and then reallocated over the trucks for that type in the trains to consolidate the munitions/fuel on the minimum of trucks. Remaining partial truckloads are then calculated. At this point, a user input is required as a decision point for how much of a partial load causes the truck to be retained or sent to the rear for reconstitution of the basic load. This user input value would be expressed as a percentage of maximum capacity for each type load, e.g., if a resupply vehicle has less than 60 tank rounds (50%) on board, send it to the ATP. To accomplish refilling the resupply vehicles, this routine calls RS_START_MOVE and schedules either ATP_ARRIVE or POL_ARRIVE as appropriate. This moves a truck out of the battalion trains.

Only after these vehicles have been dispatched, does any accounting take place. The number of trucks in the trains is updated as is the amount of ammunition/fuel on hand. RS_TRAINS_ARRIVE is also scheduled for trucks returning from the ATP, ASP and POL point. A returning truck is normally full, so no cross leveling would occur. When the resupply vehicle arrives at the trains, its amount of material on hand is added to the battalion total on hand for that type and the number of trucks in the trains is increased by one.

R. EVENT RS_ATP_ARRIVE

Each ammunition vehicle departing the battalion trains for the ATP causes an RS_ATP_ARRIVE to be scheduled. The arrival event simulates the loading proces of a battalion ammunition truck; provides an alternate loading site, the ASP, if the ATP is too busy or in a stock out condition; performs the appropriate accounting; then sends the battalion ammunition truck to the appropriate destination, scheduling either the event RS_ATP_LEAVE or RS_ASP_RETURN.

The ATP is modeled as a first in, first out queue for each type of ammunition. When an ammunition truck arrives at the ATP, the queue for that type is checked. If the loader is available and sufficient munitions are on hand, the vehicle is loaded. What consists of a sufficient amount of ammunition is input by the user as a specified level of vehicle capacity. This input is used to provide the user with flexibility to accept less than the amount

required or send the truck back to the ASP to get 100 percent of the requirement. This model assumes all munitions are always available at the ASP. At the ATP, the actual amount of munitions to be loaded is used to calculate a loading time and the amount of material transferred is added to and subtracted from the appropriate attributes. The loader is set to busy and event RS_ATP_LEAVE is scheduled in the amount of time just calculated for this truck.

Had there been no ammunition or the user's specified minimum amount not available, the battalion truck would have been scheduled to go to the ASP. In the same vein, if the loader is busy, the estimated time before this truck can complete loading is calculated. The calculation is merely the product of the number of vehicles in the queue and the mean loading time for that type of munition. Reference 9 lists mean loading times for various vehicle, ammunition and loader combinations. These times are determined by field trials. The ASP trip time is determined by the user. This trip time consists of an average ASP loading time plus the travel time from the ATP and then back to the battalion trains. This deterministic input would vary by the scenarios played around the Brigade battle. The option of not waiting at the ATP when the ASP trip time is shorter is realistic and is used to increase the amount of munitions available to the combat battalions over time. A typical mission would see trucks loaded at the ATP and then scheduled out of the ATP by event RS_ATP_LEAVE. Continued operation of the ATP is dependent on the timely and frequent

arrival of corps linehaul cargo trucks at the ATP. When a corps convoy arrives, full linehaul trucks are deposited at the ATP and empty trucks are hauled back to corps ammunition storage areas for reuse. Corps convoys are addressed in event RS_CSA_CONVOY.

S. EVENT RS_ATP_LEAVE

This event is scheduled for a particular battalion resupply vehicle by the event RS_ATP_ARRIVE. When the vehicle loading time has passed, RS_START_MOVE is called to send that vehicle back to the battalion trains and RS_TRAINS_ARRIVE is scheduled. Since a vehicle has now been loaded and departed the ATP, the server is set to idle. The queue for that ammunition type is checked for another vehicle. If there is a vehicle in the queue, it is brought in for servicing, otherwise the server remains idle. The RS_ATP_LEAVE event is a duplicate of RS_POL_LEAVE.

T. EVENT RS_ASP_RETURN

This event is only scheduled for those trucks that have been sent to the ASP. The major function of the event is to account for the time it would take to move the battalion ammunition truck to the ASP, load, and return to the ATP. The turnaround time is user input.

U. EVENT RS_POL_ARRIVE

This event is scheduled for an individual battalion fuel truck requiring a given fuel type.

A brigade POL point will be set up with a gas station type layout of service lines for the various types of fuel.

As a battalion fuel truck arrives, it enters one of the lines, is refueled and departs. The process is modeled as a first in, first out queue for each fuel type. When a battalion fuel truck arrives, the total number of gallons and DISCOM linehaul tankers available in the POL point for this specific type of fuel are calculated. A user determined number of refueling points is input.

For the sake of simplicity and to minimize the future coding requirements, only the total number of refuel points, gallons and linehaul tankers on hand are considered in aggregate for any fuel type. This precludes the requirement of tracking an individual 5000 gallon linehaul tanker through the POL operation. To keep the desired resolution for this operation, as the number of gallons dispensed equals the amount carried by a linehaul tanker, one tanker is removed from the the POL point.

When a battalion fuel truck arrives, this event first checks for the fuel type of the truck, determines the amount of that fuel available in the POL point and if there is an idle refuel point for that type. When both fuel and a server are available, a check is made to insure that the battalion fuel truck can be completely filled. If 100 percent of the requirement is not available, the truck is added to the queue until there is sufficient fuel for a refill. While at first, this may seem unreasonable, it prevents a truck from going through the queue and receiving some amount less than required and then returned to the battalion trains. It would not be unusual for a support platoon truck

to remain at the POL point until there is enough fuel, simply because there is usually no other source of fuel. The drawback to this methodology is that a DISCOM POL tanker could sit idle with a sizable amount of fuel on hand, while a battalion truck sits waiting for the arrival of the next returning DISCOM tanker to satisfy the total requirement.

In reality, a process like this would be unacceptable because it could idle transportation needlessly. The process of constructing detailed decision rules to optimize all combinations of the fuels, vehicle capacities and load breakpoints was analyzed and found to be overly complicated for the requirements of this model. Additionally, the worst case example given above would only happen when the brigade POL point is about to run out of that type of fuel.

This event also sets refuel points to busy, adds and subtracts the amount of fuel received and issued to the respective quantity attributes, places trucks in the proper queue and calculates the time to refuel a battalion fuel truck. This amount of time is then used to schedule RS_POL_LEAVE for the current truck.

V. EVENT RS_POL_LEAVE

RS_POL_LEAVE is scheduled for an individual battalion fuel truck by RS_POL_ARRIVE. When the loading time has elapsed, RS_START_MOVE is called to send the battalion fuel truck back to its parent battalion. After the truck departs, the total amount of fuel on hand in the POL point

for that type is calculated. This amount is then subtracted from that type capacity of the POL point. The capacity equals the number of linehaul trucks times their maximum capacity for that fuel type. If the difference between the two capacities is greater than or equal to a linehaul truck load, then a linehaul truck of that type is deleted from the number of trucks on hand.

The total turnaround time for a linehaul refill at the DISCOM POL point is input by the user. The event RS_TANKER_RETURN is then scheduled at the turnaround time plus the current time. The calculation of turnaround time is a deterministic function of the distance, vehicle capacity and the average waiting time at the DISCOM POL point. The DISCOM POL point is always assumed to have fuel.

As the logic of the RS_POL_LEAVE event continues, the departing battalion basic load carrier leaves one refuel point not in use. If there is sufficient fuel for another support platoon fuel truck, the queue is checked to bring up the next vehicle and refuel it. If there is no queue, the refuel point is set to idle.

W. EVENT RS_TANKER_RETURN

Each time a DISCOM linehaul tanker is emptied, RS_TANKER_RETURN is scheduled. The time lapse for scheduling has already been discussed in the previous event. When the DISCOM tanker returns to the brigade POL point, the total number of tankers and gallons on hand for that fuel type is increased appropriately.

X. EVENT RS_CSA_CONVOY

The resupply of the ATP by corps linehaul trailers is simulated by this event. The scheduling interval or frequency is a user input value and may be set as a fixed cyclic rate or as a distribution about some mean time. The total ammunition on hand for the ATP is increased by type when the CSA convoy arrives at the ATP.

IV. FUTURE ENHANCEMENTS

The proposed logistics module maps out the basic program structure for integrating the logistical functions of fuel and ammunition resupply into the STAR combat model. Although the logic is complete within the bounds of the constraining assumptions, time precluded the enhancement of several areas.

One area that should be reviewed prior to attempting the transfer of the design to code is the resupply of artillery units. If the desired level of resolution for artillery is compatible with the assumptions limiting one type of ammunition and fuel per weapons systems type, the existing logic structure can be easily adapted to artillery systems support. This is feasible if the one ammunition type for field artillery means a complete round. In terms of the resupply model, it is only relevant that the resupply vehicles deliver complete rounds to the unit and not differentiate between such rounds as high explosive, improved conventional munitions (ICM), family of scatterable mines (FASCAM) and smoke.

An additional resource consumer to be considered is the forward area rearm and refuel point (FARP). The FARP supplies the munitions and fuel necessary to replenish rotary wing aircraft operating forward in the brigade area. As written, the logic of the resupply model is generally applicable to the FARP and can be readily modified once the

appropriate time and motion study data for aircraft rearm/refuel is acquired.

The logistics model currently assumes only one ammunition type per firing system and homogeneous truck loads for ammunition support. If the model is expanded to track more than one ammunition type per system, the current STAR model already has the capability to record the rounds expended. New tables for vehicle L.O.N.'s will have to be constructed to consider a change in status for either ammunition type. The L.O.N. determination for fuel and higher units would then continue as previously outlined in event RS_EVALUATE. The number of ammunition types is not necessarily limited to two and would necessarily vary by weapons systems and units being considered. As a case in point, a mechanized infantry rifle squad with an infantry fighting vehicle might expend TOW, Dragon, Bushmaster and smallarms.

To depict an entity with more than one weapons type, the resupply model should be enriched with a mixed load methodology for ammunition. Research will be required to determine feasible loading ratios for different types of units. A mixed loading methodology would also be required for the battalion trains, ammunition transfer point (ATP) and ammunition supply point (ASP). At the resupply area itself, the current transfer methodology would require revision. A more detailed process for matching combat vehicles with resupply vehicles will have to be constructed. This would include the possibility of combat vehicles moving

between trucks to be loaded with the necessary ammunition types. In view of the level of complexity required to obtain this capability it is not apparent that such an enrichment would be worth the effort.

A more specific problem area is the definition of the company location for resupply. The combat movement decision logic can place elements of one company in tandem on different battle positions. Although there will be resupply areas designated for each company battle position, a specific logic and coding implementation effort will be required to insure that resupply integration will not degrade the present movement decision logic. Associated with this is the possible movement of combat units to an area other than that which was designated for a scheduled resupply. To address this problem some assumptions as to communications with the resupply convoy must be met and decision logic designed to alter the destination of a convoy based on the movement of the designated company. A possible method of solving this problem is to utilize the existing STAR detection and movement modules. Since STAR gives all vehicles the capability of detection, the convoy destination could be changed as a function of where Blue or Red elements are detected by the resupply convoy. A previously input list of alternative resupply areas would then be used to determine a new convoy destination.

The most important area of the supplier/shooter interface remaining to be examined is the impact of resource shortfalls on the combat forces. For example, what happens

as the battle progresses and the tank crews see their stowed load getting smaller and smaller. Will their target engagement criteria change to conserve ammunition? Will the platoon or company tactics change as the leaders realize that the unit ammunition status is dropping lower and lower? Should logic be included for cross-leveling between vehicles in the company? Should the movement decision logic include a breakpoint for fuel/ammunition status? The answers for these questions are required prior to expanding this area and must be resolved with the combat arms. There are many possible tactics that may or may not be employed. It remains a major task to determine a consensus of possible combat reactions to supply shortfalls and to develop algorithms for implementation in the combat movement logic.

As mentioned in chapter III, the STAR suppression module contains a methodology for calculating the duration of suppression times. A possible expansion of the resupply model is a modification of the current application of suppression to resupply. The process envisioned would degrade the transfer rate of resources using the suppression time delay methodology in those cases where the suppression index is less than the abort mission threshold. As an example, this could simulate a resupply in process where the unit comes under attack by mortars, takes cover for a period of time and then resumes the transfer of fuel and ammunition. This enrichment would be particularly useful in the analysis of the forward area rearm/refuel vehicle (AFARV) concept.

APPENDIX A: SDDL Output

The SDDL output presented in this appendix is the proposed structure of the logistics module.

The structure keywords are shown in Table VI.

TABLE VI SDDL KEYWORDS

STRUCTURE	INITIATOR	TERMINATOR	ESCAPE	SUBSTRUCTURE
MODULE	ROUTINE	ENDROUTINE		
	EVENT	ENDEVENT	RETURN	
BLOCK	IF	ENDIF		ELSE
	DO	LOOP	EXITLOOP	

MODULE INVOCATION KEYWORDS	CALL, SCHEDULE

In the SDDL output, words containing or connected by an asterisk (*) denotes variables that are considered key parameters in the decision logic. Words connected by or containing a percent sign (%) are variables whose values are determined by the user. Note that there are many cases where both a percent sign and an asterisk are present. Additionally, strings of words grouped within single quotation marks (') are considered single variables.

PAGE NUMBER	LINE NUMBER	MODULE NAME
2	11	EVENT RS_EVALUATE
4	62	ROUTINE RS_BATTALION_LOGIC
5	90	ROUTINE RS_ALLOCATE
7	148	ROUTINE RS_UPDATE
8	165	EVENT RS_MISSION
9	176	ROUTINE RS_START_MOVE
10	187	ROUTINE LOC
11	194	EVENT RS_CONVOY_ARRIVE
13	243	EVENT RS_OFFLOAD_CACHE
14	288	EVENT RS_CV_ARRIVE
16	332	EVENT RS_ENDLOAD
17	369	ROUTINE RS_FUEL
18	400	EVENT RS_END_FUEL
19	441	ROUTINE RS_END_MISSION
20	449	ROUTINE RS_TRUCK_UPDATE
21	467	EVENT RS_TRAINS_ARRIVE
22	511	EVENT RS_ATP_ARRIVE
23	552	EVENT RS_ATP_LEAVE
24	571	EVENT RS_ASP_RETURN
25	582	EVENT RS_POL_ARRIVE
26	621	EVENT RS_POL_LEAVE
27	660	EVENT RS_TANKER_RETURN
28	670	EVENT RS_CSA_CONVOY
29		MODULE REFERENCE TREE
31		MODULE - CROSS REFERENCE LISTING
34		CONTROL VARIBLES - CROSS REFERENCE LISTING
35		USER INPUTS - CROSS REFERENCE LISTING

```
11 EVENT RS_EVALUATE
12     ************************************************************************
13     * FOR EACH BATTALION, THIS EVENT ASSIGNS EACH COMBAT VEHICLE A LEVEL OF NEED     *
14     * (LON) BASED ON THE AMOUNT OF AMMUNITION OR FUEL USED. IT DETERMINES AN LON FOR *
15     * EACH COMPANY AND TOTALS BY TYPE THE AMOUNT OF AMMUNITION AND FUEL NEEDED BY    *
16     * THAT COMPANY                                                                   *
17     ************************************************************************
18     SCHEDULE RS_EVALUATE IN TIME*UNTIL*THE*NEXT*EVALUATION%---------------------->(  ?)
19     DO FOR EACH BATTALION IN THE BRIGADE
20         DO FOR EACH COMPANY IN THE BATTALION
21             DO FOR EACH PLATOON IN THE COMPANY
22                 DO FOR EACH ALIVE COMBAT VEHICLE IN THE PLATOON
23                     IF THE COMBAT VEHICLE HAS LESS THAN '25% OF AMMUNITION OR 30% FUEL
                        CAPACITY'
25                         CHANGE THE VEHICLE*LON ATTRIBUTE TO CRITICAL
26                     ELSE
27                         IF THE COMBAT VEHICLE HAS LESS THAN '50% OF AMMUNITION OR 65% FUEL
                            CAPACITY'
29                             CHANGE THE VEHICLE*LON ATTRIBUTE TO APPROACH CRITICAL
30                         ELSE
31                             IF THE COMBAT VEHICLE HAS LESS THAN '90% OF AMMUNITION OR 80%
                                FUEL CAPACITY'
33                                 CHANGE THE VEHICLE*LON ATTRIBUTE TO WANT
34                             ELSE
35                                 CHANGE THE VEHICLE*LON ATTRIBUTE TO FULL
36                             ENDIF
37                         ENDIF
38                     ENDIF
39                     ACCUMULATE (BY TYPE) THE AMOUNT OF AMMUNITION USED BY THE VEHICLE
40                     ACCUMULATE (BY TYPE) THE AMOUNT OF FUEL USED BY THE VEHICLE
41                     ACCUMULATE BY LON THE NUMBER OF COMBAT VEHICLES IN EACH LON CLASS
42                 LOOP
43                 UPDATE THE PLATOON ATTRIBUTE SHOWING THE NUMBER OF VEHICLES ALIVE
44                 UPDATE THE PLATOON ATTRIBUTE SHOWING THE AMOUNT OF AMMUNITION USED  SINCE
                    RESUPPLY
46                 UPDATE THE PLATOON ATTRIBUTE SHOWING THE AMOUNT OF FUEL USED SINCE
                    RESUPPLY
48                 DETERMINE THE PLATOON*LON USING LOOKUP*TABLE%
49                 ACCUMULATE NUMBER OF PLATOONS IN EACH LON CLASS
50             LOOP
51             UPDATE THE COMPANY ATTRIBUTE SHOWING THE NUMBER OF VEHICLES ALIVE
52             UPDATE THE COMPANY ATTRIBUTE SHOWING THE AMOUNT OF AMMUNITION USED SINCE
                RESUPPLY
54             UPDATE THE COMPANY ATTRIBUTE SHOWING THE AMOUNT OF FUEL USED SINCE RESUPPLY
55             DETERMINE THE COMPANY*LON USING LOOKUP*TABLE%
56         LOOP
```

```
 57         IF ANY COMPANY*SUPPLY*STATUS IS LESS THAN ONE OR ANY COMPANY*LCN IS CRITICAL
 58            CALL RS_BATTALION_LOGIC FOR CURRENT BATTALION---------------------------->(  4)
 59         ENDIF
 60      LOOP
 61   ENDEVENT
```

```
 62 RCUTINE RS_BATTALION_LOGIC
 63    ************************************************************************
 64    * THIS RCUTINE DETERMINES WITHIN EACH BATTALION, THE ORDER IN WHICH EACH COMPANY *
 65    * SHCULD BE RESUPPLIED BASED ON LCN, SUPPLY STATUS AND RESUPPLY TACTIC.  A USER  *
 66    * INPUT SETS A COMPANY RESUPPLY TACTIC FOR EACH COMPANY (CACHE OR UNIT LOCATION) *
 67    ************************************************************************
 68    DC  FOR EACH COMPANY IN THE BATTALION IN ORDER OF COMPANY*LCN THEN BY LARGEST
        NUMBER ALIVE
 70       IF COMPANY*LON IS FULL
 71    <-----EXITLOOP
 72       ELSE
 73          IF COMPANY*LCN IS NOT CRITICAL AND COMPANY*SUPPLY*STATUS IS GREATER THAN ONE
 75    <--------EXITLOOP
 76          ENDIF
 77       ENDIF
 78       IF THE COMPANY*RESUPPLY*TACTIC% IS CACHE
 79          CALL RS_ALLOCATE FOR THE CURRENT COMPANY---------------------------->(  5)
 80       ELSE
 81          THE BATTALION COMMANDER DECIDES ON A DEGREE*OF*RISK% HE IS WILLING TO
              ACCEPT WHEN SENDING RESUPPLY ASSETS TO A COMPANY POSITION
 83          DETERMINE THE COMPANY*SUPPRESSION*INDEX
 84          IF COMPANY*SUPPRESSION*INDEX IS LESS THAN THE DEGREE*OF*RISK%
 85             CALL RS_ALLOCATE FOR THE CURRENT COMPANY---------------------------->(  5)
 86          ENDIF
 87       ENDIF
 88    LOOP
 89 ENDRCUTINE
```

```
 90 ROUTINE RS_ALLOCATE
 91     ************************************************************************
 92     * THIS ROUTINE IS CALLED FOR EACH COMPANY IN THE ORDER DESIGNATED BY   *
 93     * RS_BATTALION_LOGIC.  IT ALLOCATES AMMUNITION AND FUEL ASSETS TO THE COMPANY *
 94     * BEING CONSIDERED BASED ON AVAILABILITY AND THE EFFICIENT USE OF TRANSPORTATION *
 95     * IT FORMS A CONVOY FOR THE COMPANY CURRENTLY BEING CONSIDERED.        *
 96     ************************************************************************
 97     DO FOR EACH AMMUNITION OR FUEL TYPE
 98        IF THE LOOP IS ON FUEL
 99           IF THE COMPANY*RESUPPLY*TACTIC% IS CACHE AND THE COMPANY*LON IS NOT CRITICAL
101     <--------EXITLOOP
102           ENDIF
103        ENDIF
104        IF THE COMPANY*LON IS CRITICAL AND THE COMPANY*SUPPLY*STATUS IS   GREATER THAN
            ONE
106           DETERMINE THE AMMUNITION/FUEL STILL NEEDED (REQUESTED - ALLOCATED)
107           IF THE AMMUNITION/FUEL STILL NEEDED IS LESS THAN '25% OF THE AMMUNITION/FUEL
               REQUESTED'
109     <--------EXITLOOP
110           ELSE
111              ADJUST THE AMOUNT REQUESTED TO EQUAL THE AMOUNT STILL NEEDED
112           ENDIF
113        ENDIF
114        IF THE NUMBER OF CRITICAL COMPANIES IN THE BATTALION IS GREATER THAN ONE
116           DETERMINE THE NUMBER OF TRUCKS ALIVE
117           IF THE NUMBER OF TRUCKS ON HAND IS LESS THAN THE NUMBER OF CRITICAL
               COMPANIES
119              RESERVE (NUMBER OF TRUCKS - 1) TRUCKS FOR THE OTHER CRITICAL COMPANIES
120           ELSE
121              RESERVE (INTEGER(NUMBER OF TRUCKS/NUMBER CRITICAL COMPANIES))(NUMBER OF
                  CRITICAL COMPANIES -1) TRUCKS FOR THE OTHER CRITICAL COMPANIES
123           ENDIF
124           TEMPORARILY DECREASE THE AMOUNT ON HAND BY THE AMOUNT ON THE RESERVED TRUCKS
126        ENDIF
127        ALLOCATE THE COMPANY THE MINIMUM OF THE AMOUNT ON HAND OR THE AMOUNT REQUESTED
129        DETERMINE THE NUMBER OF FULL TRUCKLOADS REQUIRED TO MOVE THE   AMMUNITION/FUEL
            ALLOCATED
131        DETERMINE THE PERCENTAGE OF A LOAD FOR ANY PARTIAL LOAD REMAINING
132        CALL RS_UPDATE FOR THE NUMBER OF FULL TRUCKLOADS REQUIRED---------------->(  7)
133        IF THE PARTIAL LOAD IS GREATER THAN '50% OF A TRUCK LOAD' AND THE COMPANY*LON
            IS APPROACHING CRITICAL
135           CALL RS_UPDATE FOR THE ADDITION TRUCKLOAD TO CARRY THE PARTIAL LOAD--->(  7)
136        ELSE
```

```
LINE
 138          IF THE PARTIAL LOAD IS GREATER THAN '25% OF A TRUCK LOAD' AND THE
                COMPANY*LCN IS IS CRITICAL
 140              CALL RS_UPDATE FOR THE ADDITIONAL TRUCKLOAD TO CARRY THE PARTIAL
                    LOAD------------------------------------------------------->(  7)
 142          ENDIF
 143       ENDIF
 144    LOOP
 145    RELEASE ALL RESERVED TRUCKS
 146    SCHEDULE RS_MISSION IN 'ALLOCATION PROCESS TIME LAG*'------------------->(  8)
 147 ENDPROCTIME
```

```
148 RCUTINE RS_UPDATE
149     ********************************************************************
150     * THIS ROUTINE IS CALLED BY RS_ALLOCATE FOR A SPECIFIC AMMUNITION/FUEL TYPE. IT *
151     * TRANSFERS TRUCKS AND STOCKS FROM THE TRAINS TO THE CONVOY BEING FORMED FOR    *
152     * THE COMPANY CURRENTLY BEING CONSIDERED.                                       *
153     ********************************************************************
154     UPDATE THE CONVOY NUMBER OF TRUCKS ATTRIBUTE TO THE TOTAL TRUCKS ASSIGNED
156     UPDATE THE CONVOY AMMUNITION/FUEL TYPE ATTRIBUTES TO REFLECT THE AMOUNT ON HAND
158     UPDATE THE TRUCKS OWNER ATTRIBUTE TO SHOW THAT IT BELONGS TO THE CONVOY
160     DECREMENT THE TRAINS AMMUNITION/FUEL TYPE ATTRIBUTE BY THE AMOUNT SENT WITH THE
          CONVOY
162     DECREMENT BY AMMUNITION/FUEL TYPE THE TRAINS ATTRIBUTE SHOWING THE NUMBER OF
          TRUCKS ON HAND
164 ENDROUTINE
```

```
  165 EVENT RS_MISSION
  166     ********************************************************************************
  167     * THIS EVENT IS SCHEDULED BY RS_ALLOCATE FOR EACH COMPANY IN A USER INPUT TIME *
  168     * LAG THAT SIMULATES THE TIME REQUIRED TO PROCESS A SUPPLY REQUEST AND ASSEMBLE *
  169     * A CONVOY.                                                                    *
  170     ********************************************************************************
  171     CALL RS_START_MOVE TO MOVE THE CONVOY TO THE DESIGNATED COMPANY RESUPPLY
            AREA------------------------------------------------------------------->(  9)
  173     ADD ONE TO THE COMPANY*SUPPLY*STATUS
  174     SCHEDULE RS_CONVOY_ARRIVE TO DETERMINE IF THE CONVOY HAS ARRIVED---------->( 11)
  175 ENDEVENT
```

```
176 ROUTINE RS_START_MOVE
177    ************************************************************************
178    * THIS ROUTINE IS CALLED WHENEVER A VEHICLE OR CONVOY NEEDS TO BE MOVED ON THE *
179    * TERRAIN MODEL.                                                       *
180    ************************************************************************
181    DO FOR EACH VEHICLE
182       RESET VEHICLE AREA START ATTRIBUTE TO PRESENT LOCATION
183       RESET VEHICLE AREA END ATTRIBUTE TO THE DESTINATION
184       CALL LOC---------------------------------------------------------->( 10)
185    LOOP
186 ENDROUTINE
```

```
  187 ROUTINE LCC
  188     ********************************************************************
  189     * THIS ROUTINE IS PART OF THE STAR GROUND COMBAT MODEL AND IS       *
  190     * A PRIMARY INTERFACE BETWEEN THE LOGISTICAL PROCESS AND THE COMBAT PROCESS *
  191     * IT MOVES ALL VEHICLES FROM THEIR START POSITION TO THEIR DESTINATION *
  192     ********************************************************************
  193 ENDROUTINE
```

```
194 EVENT RS_CONVCY_ARRIVE
195    ***********************************************************************
196    * THIS EVENT IS SCHEDULED FOR EACH CONVOY AND DETERMINES WHEN THE CONVOY HAS    *
197    * REACHED ITS DESTINATION.  DEPENDING ON THE RESUPPLY TACTIC, IT THEN STARTS TO *
198    * BUILD A CACHE OR TO RESUPPLY THE COMPANY.  COMBAT VEHICLES ARE MOVED TO THE   *
199    * COMPANY RESUPPLY AREA FOR AMMUNITION OR FUEL.                                 *
200    ***********************************************************************
201    IF THE CONVOY HAS ARRIVED AT COMPANY RESUPPLY AREA
202       DO FOR EACH AMMUNITION/FUEL TYPE AVAILABLE IN THE CONVOY
203          DETERMINE THE AMOUNT OF AMMUNITION/FUEL THAT ARRIVED ON THE CONVOY
204          DETERMINE THE NUMBER OF TRUCKS ON HAND
205       LOOP
206       DETERMINE THE AREA*SUPPRESSION*INDEX
207       IF THE AREA*SUPPRESSION*INDEX IS LESS THAN THE ABORT*MISSION*THRESHOLD%
208          DETERMINE THE COMPANY*RESUPPLY*TACTIC%
209          IF THE COMPANY*RESUPPLY*TACTIC% IS CACHE
210             DETERMINE TIME TO OFFLOAD TRUCKS TO GROUND
211             SCHEDULE RS_OFFLOAD_CACHE----------------------------------->( 13)
212          ELSE
213             DO FOR EACH AMMUNITION TYPE
214                IF THE NUMBER OF AMMUNITION TRUCKS IS EQUAL TO ZERO AND THE NUMBER OF
                      FUEL TRUCKS IS GREATER THAN ZERO
216                   CALL RS_START_MOVE TO MOVE TWO COMBAT VEHICLES NEEDING THIS
                         AMMUNITION TYPE BY LON TO THE COMPANY RESUPPLY AREA TO
                         REFUEL------------------------------------------->(  9)
219                   SCHEDULE RS_CV_ARRIVE--------------------------------->( 14)
220                ELSE
221                   CALL RS_START_MOVE TO MOVE TWO COMBAT VEHICLES NEEDING THIS
                         AMMUNITION TYPE PER TRUCK BY LON TO THE COMPANY RESUPPLY
                         AREA--------------------------------------------->(  9)
224                   SCHEDULE RS_CV_ARRIVE--------------------------------->( 14)
225                ENDIF
226             LOOP
227          ENDIF
228       ELSE
229          CALL RS_END_MISSION----------------------------------------------->( 19)
230       ENDIF
231    ELSE
```

```
232          IF THE CONVOY TRUCKS ARE ALIVE
234             SCHEDULE RS_CONVOY_ARRIVE------------------------------------------>( 11 )
235          ELSE
236             DO FOR EACH AMMUNITION/FUEL TYPE
237                ADJUST COMPANY AMOUNT ALLOCATED ATTRIBUTE BY THE AMOUNT OF THE CONVOY
                    AMMUNITION/FUEL ATTRIBUTE
239             LOOP
240          ENDIF
241       ENDIF
242    ENDEVENT
```

```
EVENT RS_OFFLOAD_CACHE
   ********************************************************************************
   * WHEN THE COMPANY RESUPPLY TACTIC IS CACHE, THIS EVENT COMPLETES THE CACHE AND *
   * STARTS MOVING THE CONVOY BACK TO THE BATTALION TRAINS AREA. IF THE COMPANY IS *
   * AT THIS LOCATION THEIR RESUPPLY IS STARTED                                    *
   ********************************************************************************
   DO FOR EACH AMMUNITION TYPE
      UPDATE CACHE NUMBER OF PILES ATTRIBUTE BY NUMBER OF AMMUNITION TRUCKS
      UPDATE CACHE AMMUNITION TYPE ATTRIBUTE BY AMOUNT DELIVERED BY THE CONVOY
      SET CONVOY AMMUNITION TYPE AMOUNT ATTRIBUTE TO ZERO
      DO FOR EACH TRUCK
         SET TRUCK AMMUNITION TYPE ATTRIBUTE TO ZERO
      LOOP
   LOOP
   IF COMPANY AT THIS LOCATION
      DO FOR EACH AMMUNITION TYPE
         DETERMINE THE NUMBER OF PILES OF THIS AMMUNITION TYPE
         IF THE NUMBER OF OF PILES IS EQUAL TO ZERO AND THE NUMBER OF FUEL TRUCKS IS
          GREATER THAN ZERO
            CALL RS_START_MOVE TO MOVE TWO COMBAT VEHICLES NEEDING THIS AMMUNITION
             TYPE BY LCN TO THE COMPANY RESUPPLY AREA TO REFUEL---------------->(  9)
            SCHEDULE RS_CV_ARRIVE FOR THESE COMBAT VEHICLES-------------------->( 14)
         ELSE
            CALL RS_START_MOVE TO MOVE TWO COMBAT VEHICLES PER PILE OF THIS TYPE OF
             AMMUNITION BY LCN TO THE COMPANY RESUPPLY AREA TO REARM----------->(  9)
            SCHEDULE RS_CV_ARRIVE--------------------------------------------->( 14)
         ENDIF
      LOOP
   ELSE
      SCHEDULE RS_CV_ARRIVE------------------------------------------------->( 14)
   ENDIF
   DO FOR EACH TYPE OF FUEL
      SET  CONVOY NUMBER OF FUEL TRUCKS ATTRIBUTE TO ZERO
      UPDATE CACHE NUMBER OF FUEL TRUCKS ATTRIBUTE BY THE NUMBER IN THE CONVOY
      UPDATE  CACHE FUEL TYPE ATTRIBUTE BY QUANTITY LEFT BY CONVOY
      SET CONVOY FUEL TYPE ATTRIBUTE TO ZERO
   LOOP
   CALL RS_TRUCK_UPDATE FOR CONVOY TRUCKS---------------------------------->( 20)
ENDEVENT
```

```
283 EVENT RS_CV_ARRIVE
284    ***************************************************************************
285    * THIS EVENT IS SCHEDULED FOR COMBAT VEHICLES WHICH NEED A SPECIFIC AMMUNITION   *
286    * TYPE. IT DETERMINES WHEN THE COMBAT VEHICLES HAVE ARRIVED AT THEIR DESTINATION *
287    * (BATTLE POSITION OR COMPANY RESUPPLY AREA). IF THE LOCATION IS THE COMPANY     *
288    * RESUPPLY AREA, IT STARTS THE REARMING/REFUELING OF THE COMPANY.                *
289    ***************************************************************************
290    IF THE COMBAT VEHICLES HAVE ARRIVED AT THEIR DESTINATION
291       DETERMINE THE LOCATION OF THE COMBAT VEHICLES
292       IF THE LOCATION IS THE COMPANY RESUPPLY AREA
293          DETERMINE THE AREA*SUPPRESSION*INDEX
294          IF THE AREA*SUPPRESSION*INDEX IS LESS THAN THE ABORT*MISSION*THRESHOLD%
295             DO FOR EACH COMBAT VEHICLE THAT ARRIVED
296                IF THE AMOUNT AMMUNITION ON HAND IS GREATER THAN THE AMOUNT NEEDED
297                   UPDATE THE COMBAT VEHICLE AMMUNITION TYPE ATTRIBUTE TO FULL
298                   DECREMENT THE CONVOY/CACHE AMMUNITION TYPE BY THE AMOUNT NEEDED
299                   DETERMINE THE TIME REQUIRED TO REARM
300                   SCHEDULE RS_ENDLOAD------------------------------------------>( 16)
301                ELSE
302                   IF AMOUNT ON HAND EQUALS ZERO
303                      CALL RS_FUEL---------------------------------------------->( 17)
304 <--------------------RETURN
305                   ENDIF
306                   UPDATE THE COMBAT VEHICLE AMMUNTION TYPE ATTRIBUTE BY THE AMOUNT ON
                       HAND
308                   SET THE CONVOY/CACHE AMMUNITION TYPE ATTRIBUTE TO ZERO
309                   DETERMINE THE TIME REQUIRED TO REARM
310                   SCHEDULE RS_ENDLOAD------------------------------------------>( 16)
311                ENDIF
312             LOOP
313          ELSE
314             CALL RS_END_MISSION--------------------------------------------->( 19)
315             CALL RS_START_MOVE TO MOVE ALL COMBAT VEHICLES IN THE COMPANY RESUPPLY
                 AREA BACK TO THEIR BATTLE POSITIONS------------------------------>(  9)
317          ENDIF
318       ELSE
319          IF CACHE EXISTS
320             CALL RS_START_MOVE TO MOVE TWO COMBAT VEHICLES PER PILE BY LON TO THE
                 COMPANY RESUPPLY AREA-------------------------------------------->(  9)
322             SCHEDULE RS_CV_ARRIVE------------------------------------------->( 14)
323          ENDIF
324       ENDIF
325    ELSE
```

```
327         IF COMBAT VEHICLES ARE ALIVE
328            SCHEDULE RS_CV_ARRIVE------------------------------------------------->( 14)
329         ENDIF
330      ENDIF
331   ENDEVENT
```

```
332 EVENT RS_ENDLOAD
333     ************************************************************************
334     * THIS EVENT IS SCHEDULED FOR A COMBAT VEHICLE .  IT COMPLETES THE REFUELING     *
335     * PROCESS AND MOVES THE COMBAT VEHICLE BACK TO ITS BATTLE POSITION.  IF ANOTHER  *
336     * COMBAT VEHICLE IS WAITING IN THE QUEUE FOR THIS FUEL TYPE, THE EVENT WILL      *
337     * START THE REFUEL PROCESS FOR IT. THE REFUELING PROCESS WILL CONTINUE UNTIL THE *
338     * FUEL IS EXHAUSTED OR ALL THE COMBAT VEHICLES HAVE BEEN REFUELED.  IT CHECKS IF *
339     * THE RESUPPLY MISSION HAS BEEN COMPLETED.                                       *
340     ************************************************************************
341     UPDATE VEHICLE*LCN TO FULL
342     INCREASE BY AMMUNITION TYPE THE NUMBER OF VEHICLES REARMED
343     INITIALIZE LOOP AND MISSION COUNTERS TO ZERO
344     DO FOR EACH AMMUNITON/FUEL TYPE
345        ADD ONE TO THE LOOP COUNTER
346        IF THE QUANTITY ON HAND EQUALS ZERO OR FOR THIS AMMUNITION/FUEL TYPE THE NUMBER
            OF VEHICLES ALIVE EQUALS THE NUMBER VEHICLES FULL
349           ADD ONE TO END MISSION COUNTER
350        ENDIF
351     LOOP
352     IF END MISSION COUNTER EQUALS LOOP COUNTER
353        CALL RS_END_MISSION-------------------------------------------------->( 19)
354     ENDIF
355     DETERMINE THE AREA*SUPPRESSION*INDEX
356     IF THE AREA*SUPPRESSION*INDEX IS LESS THAN THE ABORT*MISSION*THRESHOLD%
357        CALL RS_FUEL--------------------------------------------------------->( 17)
358        IF THE AMOUNT OF  AMMUNITION ON HAND IS GREATER THAN ZERO
359           CALL RS_START_MOVE TO MOVE THE NEXT COMBAT VEHICLE BY LCN TO THE COMPANY
               RESUPPLY AREA-------------------------------------------------->(  9)
361           SCHEDULE RS_CV_ARRIVE FOR THESE VEHILCES----------------------->( 14)
362        ENDIF
363     ELSE
364        CALL RS_END_MISSION-------------------------------------------------->( 19)
365        CALL RS_START_MOVE TO MOVE ALL COMBAT VEHICLES IN THE COMPANY RESUPPLY AREA
            BACK TO THEIR BATTLE POSITIONS--------------------------------------->(  9)
367     ENDIF
368 ENDEVENT
```

```
369 ROUTINE RS_FUEL
370     ********************************************************************************
371     * THIS ROUTINE IS CALLED FOR A VEHICLE NEEDING A SPECIFIC FUEL TYPE. IF A REFUEL *
372     * POINT IS IDLE, THE VEHICLE STARTS REFUELING, OTHERWIRE THE VEHICLE IS PLACED   *
373     * IN A QUEUE                                                                     *
374     ********************************************************************************
375     DEFINE THE COMPANY POL QUEUE AS  FIRST IN FIRST OUT
376     DETERMINE IF A REFUEL POINT IS IDLE
377     IF REFUEL POINT IS IDLE
378        DETERMINE THE AMOUNT OF FUEL ON HAND
379        IF THE FUEL ON HAND IS GREATER THAN THE FUEL NEEDED
380           UPDATE THE COMBAT VEHICLE FUEL TYPE ATTRIBUTE TO FULL
381           DECREMENT THE CONVOY/CACHE FUEL TYPE ATTRIBUTE BY THE AMOUNT NEEDED
382           DETERMINE THE TIME REQUIRED TO REFUEL WITH THE AMOUNT NEEDED
383           SCHEDULE RS_END_FUEL------------------------------------------------>( 18)
384        ELSE
385           UPDATE THE COMBAT VEHICLE FUEL TYPE ATTRIBUTE BY THE AMOUNT ON HAND
387           DETERMINE THE TIME REQUIRED TO REFUEL WITH THE AMOUNT ON HAND
388           SCHEDULE RS_END_FUEL------------------------------------------------>( 18)
389           SET THE CONVOY/CACHE FUEL TYPE ATTRIBUTE TO ZERO
390        ENDIF
391     ELSE
392        IF THE AMOUNT OF THE FUEL TYPE IS GREATER THAN ZERO
393           ADD COMBAT VEHICLE TO THE COMPANY POL QUEUE
394        ELSE
395           CALL RS_START_MOVE TO MOVE THE COMBAT VEHICLE BACK TO ITS BATTLE
                POSITION------------------------------------------------------------>(  9)
397        ENDIF
398     ENDIF
399 ENDROUTINE
```

```
400 EVENT RS_END_FUEL
401     ********************************************************************************
402     * THIS EVENT IS SCHEDULED FOR A COMBAT VEHICLE.  IT COMPLETES THE REFUELING    *
403     * PROCESS AND MOVES THE COMBAT VEHICLE BACK TO ITS BATTLE POSITION.  IF ANOTHER *
404     * COMBAT VEHICLE IS WAITING IN THE QUEUE FOR THIS FUEL TYPE, THE EVENT WILL     *
405     * START THE REFUEL PROCESS FOR IT.  THIS EVENT ALSO CHECKS FOR THE COMPLETION OF *
406     * THE MISSION.                                                                 *
407     ********************************************************************************
408     UPDATE VEHICLE*LOC TO FULL
409     INCREASE THE NUMBER OF VEHICLES REFUELED BY ONE
410     SET THE FUEL POINT TO IDLE
411     CALL RS_START_MOVE TO MOVE THE COMBAT VEHICLE BACK TO ITS BATTLE POSITION--->(  9)
413     INITIALIZE LOOP AND MISSION COUNTERS TO ZERO
414     DO FOR EACH AMMUNITON/FUEL TYPE
415        ADD ONE TO THE LOOP COUNTER
416        IF THE QUANTITY ON HAND EQUALS ZERO OR FOR THIS AMMUNITION/FUEL TYPE THE NUMBER
            OF VEHICLES ALIVE EQUALS THE NUMBER VEHICLES FULL
419           ADD ONE TO END MISSION COUNTER
420        ENDIF
421     LOOP
422     IF END MISSION COUNTER EQUALS LOOP COUNTER
423        CALL RS_END_MISSION-------------------------------------------------->( 19)
424     ENDIF
425     IF THERE IS A COMBAT VEHICLE IN THE COMPANY POL QUEUE
426        IF THE AMOUNT OF FUEL ON HAND IS GREATER THAN ZERO
427           TAKE THE FIRST VEHICLE IN THE QUEUE
428           CALL RS_FUEL--------------------------------------------------->( 17)
429        ENDIF
430     ELSE
431        IF THE AMOUNT FUEL ON HAND IS GREATER THAN ZERO AND ANY AMMUNITION TYPE AMOUNT
            ON HAND IS EQUAL TO ZERO
432           DO FOR EACH AMMUNITION TYPE EQUAL TO ZERO
434              CALL RS_START_MOVE TO MOVE THE NEXT COMBAT VEHICLE BY LON TO THE COMPANY
                  RESUPPLY AREA TO REFUEL------------------------------------->(  9)
436              SCHEDULE RS_CV_ARRIVE--------------------------------------->( 14)
437           LOOP
438        ENDIF
439     ENDIF
440 ENDEVENT
```

```
441 ROUTINE RS_END_MISSION
442     ************************************************************************
443     * THIS ROUTINE IS CALLED WHENEVER A RESUPPLY MISSION HAS BEEN TERMINATED AND IS *
444     * USED TO INDICATE THAT THE SUPPLY STATUS HAS CHANGED.                  *
445     ************************************************************************
446     SUBTRACT ONE FROM THE COMPANY*SUPPLY*STATUS
447     CALL RS_TRUCK_UPDATE FOR ALL CONVOY/CACHE TRUCKS---------------------------->( 20)
448 ENDROUTINE
```

```
 449 ROUTINE RS_TRUCK_UPDATE
 450     ************************************************************************
 451     * THIS ROUTINE IS CALLED FOR CONVOY/CACHE TRUCKS TO ADJUST THE AMOUNT OF *
 452     * AMMUNITION/FUEL ON EACH TRUCK PRIOR TO THEIR MOVE BACK TO THE BATTALION TRAINS *
 453     * AREA.                                                                  *
 454     ************************************************************************
 455     DO FOR EACH AMMUNITION/FUEL TYPE
 456        DETERMINE THE AMOUNT OF AMMUNITION/FUEL LEFT ON HAND
 457        DETERMINE THE NUMBER OF TRUCKS ALIVE
 458        DETERMINE THE AVERAGE TRUCKLOAD
 459        DO FOR EACH TRUCK ALIVE
 460           UPDATE TRUCKLOAD SIZE ATTRIBUTE TO AVERAGE LOAD
 461        LOOP
 462     LOOP
 463     CALL RS_START_MOVE TO MOVE COMPANY/CACHE TRUCKS BACK TO THE BATTALION TRAINS
          AREA---------------------------------------------------------->(  9)
 465     SCHEDULE RS_TRAINS_ARRIVE------------------------------------------>( 21)
 466 ENDROUTINE
```

```
467 EVENT RS_TRAINS_ARRIVE
468     ********************************************************************************
469     * THIS ROUTINE IS SCHEDULED FOR ALL CONVOYS/TRUCKS RETURNING TO THE BATTALION  *
470     * TRAINS AREA.  IT CONSOLIDATES THE AMMUNITON/FUEL LEFT ON THE TRUCKS RETURNING *
471     * FROM A RESUPPLY MISSION TO THE SMALLEST NUMBER OF TRUCKS.  BASED ON A USER    *
472     * INPUT THRESHOLD OF PARTIAL LOADS, ITS SENDS TRUCKS TO THE ATP OR BRIGADE POL  *
473     * POINT FOR REPLENISHMENT.  FOR TRUCKS RETURNING FROM THE ATP, ASP OR POL      *
474     * POINT IT ADDS THE TRUCK TO THE BATTALION TRAINS.                             *
475     ********************************************************************************
476     IF THE CONVOY HAS ARRIVED AT THE BATTALION TRAINS AREA
477        DO FOR EACH AMMUNITION/FUEL TYPE
478           DETERMINE THE AMOUNT ON HAND IN THE CONVOY
479           DO FOR EACH TRUCK
480              IF AMMUNITION/FUEL LEFT IS GREATER THAN A TRUCKLOAD
481                 UPDATE THE TRUCK LOAD SIZE ATTRIBUTE TO REFLECT FULL LOAD
482                 SUBTRACT LOAD FROM AMOUNT LEFT
483              ELSE
484                 UPDATE TRUCKLOAD SIZE ATTRIBUTE TO REFLECT PERCENT OF LOAD LEFT ON
                    HAND
486              ENDIF
487           LOOP
488           DO FOR EACH TRUCK
489              DETERMINE THE PERCENT LOAD
490              IF THE PERCENT LOAD IS LESS THAN '50% OF A TRUCK LOAD'
491                 DETERMINE THE TYPE OF TRUCK CARGO (AMMUNITION OR POL)
492                 IF THE TRUCK CARRIES AMMUNITION
493                    CALL RS_START_MOVE TO MOVE THE TRUCK TO THE ATP------------->(  9)
494                    SCHEDULE RS_ATP_ARRIVE-------------------------------------->( 22)
495                 ELSE
496                    CALL RS_START_MOVE TO MOVE THE TRUCK TO THE BRIGADE POL POINT>(  9)
497                    SCHEDULE RS_POL_ARRIVE-------------------------------------->( 25)
498                 ENDIF
499              ELSE
500                 UPDATE BATTALION TRAINS AMMUNITION/FUEL ATTRIBUTE BY AMOUNT RETURNED
501                 UPDATE BATTALION TRAINS AMMUNITION/FUEL TRUCK NUMBER ATTRIBUTE
502              ENDIF
503           LOOP
504        LOOP
505     ELSE
506        IF TRUCKS IN THE CONVOY ARE ALIVE
507           SCHEDULE RS_TRAINS_ARRIVE----------------------------------------->( 21)
508        ENDIF
509     ENDIF
510 ENDEVENT
```

```
511 EVENT RS_ATP_ARRIVE
512     ********************************************************************************
513     * THIS EVENT IS SCHEDULED FOR EVERY BATTALION AMMUNITION TRUCK SENT TO THE ATP. *
514     * IF THE ATP IS TOO BUSY OR IN A STOCKOUT POSITION FOR THE AMMUNITION TYPE      *
515     * NEEDED, IT SENDS THE TRUCK TO THE ASP. IF THE TRUCKS REMAINS AT THE ATP, THE  *
516     * EVENT STARTS THE RELOAD PROCESS OR HAS THE TRUCK WAIT IN A QUEUE              *
517     ********************************************************************************
518     DEFINE THE ATP AMMUNITION TYPE QUEUES AS FIRST IN FIRST OUT
519     IF THE BATTALION AMMUNITION TRUCK HAS ARRIVED AT THE ATP
520         IF THE LOADER IS IDLE
521             IF THE AMOUNT ON HAND OF THE AMMUNITION TYPE IS GREATER THAN '50% OF THE
                 AMMUNITION NEEDED'
523                 UPDATE THE BATTALION TRUCK AMMUNITION TYPE ATTRIBUTE BY THE MINIMUM OF
                     THE AMOUNT ON HAND OR THE AMOUNT NEEDED
525                 DECREMENT THE ATP AMMUNITION TYPE ATTRIBUTE BY THE MINIMUM OF THE AMOUNT
                     ON HAND OR THE AMOUNT NEEDED
527                 DETERMINE THE TIME REQUIRED TO LOAD THE AMMUNITION
528                 SCHEDULE RS_ATP_LEAVE----------------------------------------->( 23)
529                 SET THE LOADER TO BUSY
530             ELSE
531                 SCHEDULE RS_ASP_RETURN---------------------------------------->( 24)
532             ENDIF
533         ELSE
534             IF THE AMOUNT ON HAND OF THE AMMUNITION TYPE IS LESS THAN '50% OF THE
                 AMMUNITION NEEDED' OR THE QUEUE TIME IS GREATER THAN THE 'ASP TRIP LENGTH%'
536                 SCHEDULE RS_ASP_RETURN---------------------------------------->( 24)
537             ELSE
538                 ADD THE BATTALION AMMUNITION TRUCK TO THE ATP QUEUE FOR THAT AMMUNITION
                     TYPE
540                 UPDATE THE BATTALION AMMUNITION TRUCK AMMUNITION TYPE ATTRIBUTE BY THE
                     MINIMUM OF THE AMOUNT ON HAND OR THE AMOUNT NEEDED
542                 DECREMENT THE ATP AMMUNITION TYPE ATTRIBUTE BY THE MINIMUM OF THE AMOUNT
                     ON HAND OR THE AMOUNT NEEDED
544             ENDIF
545         ENDIF
546     ELSE
547         IF THE BATTALION AMMUNITION TRUCK IS STILL ALIVE
548             SCHEDULE RS_ATP_ARRIVE---------------------------------------->( 22)
549         ENDIF
550     ENDIF
551 ENDEVENT
```

```
552 EVENT RS_ATP_LEAVE
553    ***************************************************************************
554    * THIS EVENT IS SCHEDULED FOR EVERY BATTALION AMMUNITION TRUCK RELOADED AT THE    *
555    * ATP. IT COMPLETES THE RELOAD PROCESS AND SENDS THE TRUCK BACK TO THE BATTALION *
556    * TRAINS AREA.  IT CONTINUES THE RELOAD PROCESS FOR ANY TRUCKS WAITING IN THE     *
557    * QUEUE FOR THE SAME AMMUNITION TYPE.                                             *
558    ***************************************************************************
559    DETERMINE THE AMMUNITION TYPE OF THE BATTALION AMMUNITION TRUCK
560    CALL RS_START_MOVE TO MOVE THE BATTALION TRUCK BACK TO THE BATTALION TRAINS
         AREA-------------------------------------------------------------->(  9)
562    SCHEDULE RS_TRAINS_ARRIVE----------------------------------------------->( 21)
563    SET LOADER TO IDLE
564    IF THERE IS A BATTALION AMMUNITION TRUCK IN THE ATP QUEUE FOR THAT AMMUNITION TYPE
566       TAKE THE NEXT TRUCK IN THE ATP QUEUE
567       SCHEDULE RS_ATP_LEAVE------------------------------------------------>( 23)
568       UPDATE THE LOADER TO BUSY
569    ENDIF
570 ENDEVENT
```

```
571 EVENT RS_ASP_RETURN
572     ********************************************************************************
573     * THIS EVENT IS SCHEDULED FOR ALL BATTALION AMMUNITION SENT TO THE ASP.  IT     *
574     * ACCOUNTS FOR THE TIME IT WOULD TAKE FOR A TRUCK TO MAKE A ROUND TRIP FROM THE *
575     * ATP TO THE ASP.  IT THEN SENDS THE TRUCK BACK TO THE BATTALION TRAINS AREA.   *
576     ********************************************************************************
577     UPDATE BATTALION AMMUNITION TRUCK AMMUNITION TYPE ATTRIBUTE TO FULL
578     CALL RS_START_MOVE TO MOVE THE BATTALION TRUCK BACK TO THE BATTALION TRAINS
          AREA---------------------------------------------------------->( 9)
580     SCHEDULE RS_TRAINS_ARRIVE------------------------------------------>( 2)
581 ENDEVENT
```

```
582 EVENT RS_POL_ARRIVE
583    ********************************************************************************
584    * THIS EVENT IS SCHEDULED FOR EVERY BATTALION FUEL TRUCK SENT TO THE BRIGADE POL *
585    * POINT. WHEN THE TRUCK ARRIVES, THE EVENT STARTS THE REFILL PROCESS OR HAS THE  *
586    * THE TRUCK WAIT IN A QUEUE FOR THAT FUEL TYPE.                                  *
587    ********************************************************************************
588    DEFINE BRIGADE FUEL TYPE POL QUEUES AS FIRST IN FIRST OUT
589    IF THE BATTALION FUEL TRUCK HAS ARRIVED AT THE BRIGADE POL POINT
590       DETERMINE THE POL TRUCK FUEL TYPE
591       DETERMINE THE AMOUNT OF THAT FUEL TYPE ON HAND IN THE BRIGADE POL POINT
592       DETERMINE THE 'NUMBER REFUEL POINTS%' IDLE FOR THAT FUEL TYPE
593       IF A REFUEL POINT IS IDLE
594          IF THE AMOUNT OF THE FUEL TYPE ON HAND IS GREATER THAN '100% OF THE FUEL
595           NEEDED'
596             IF THERE IS A BATTALION FUEL TRUCK IN THE BRIGADE POL QUEUE
597                FILE ARRIVING TRUCK IN THE BRIGADE POL QUEUE
598                TAKE THE NEXT TRUCK IN THE QUEUE
599             ENDIF
600             UPDATE THE BATTALION FUEL TRUCK FUEL TYPE ATTRIBUTE BY THE AMOUNT OF
601              FUEL NEEDED
602             DECREMENT THE BRIGADE POL POINT FUEL TYPE ATTRIBUTE BY THE AMOUNT OF
603              FUEL NEEDED
604             SET THE REFUEL POINT TO BUSY
605             SCHEDULE RS_POL_LEAVE-------------------------------------------->( 26)
606          ELSE
607             ADD THE BATTALION FUEL TRUCK TO THE BRIGADE POL QUEUE FOR THAT FUEL TYPE
608          ENDIF
609       ELSE
610          ADD THE BATTALION FUEL TRUCK TO THE BRIGADE POL QUEUE FOR THAT FUEL TYPE
611       ENDIF
612    ELSE
613       IF THE BATTALION FUEL TRUCK IS STILL ALIVE
614          SCHEDULE RS_POL_ARRIVE------------------------------------------------>( 25)
615       ENDIF
616    ENDIF
617 ENDEVENT
```

```
 621 EVENT RS_POL_LEAVE
 622    ********************************************************************************
 623    * THIS EVENT IS SCHEDULED FOR EVERY BATTALION FUEL TRUCK REFUELED AT THE BRIGADE *
 624    * POL POINT.  IT COMPLETES THE REFILL PROCESS AND SENDS THE TRUCK BACK TO THE    *
 625    * BATTALION TRAINS AREA.  IF A POL POINT TANKER HAS BEEN EMPTIED, IT SCHEDULES   *
 626    * RS_TANKER_RETURN.                                                             *
 627    ********************************************************************************
 628    DETERMINE FUEL TYPE OF THE BATTALION FUEL TRUCK
 629    CALL RS_START_MOVE TO MOVE THE BATTALION FUEL TRUCK BACK TO THE BATTALION
         TRAINS AREA---------------------------------------------------------->(  9)
 631    SCHEDULE RS_TRAINS_ARRIVE-------------------------------------------->( 21)
 632    DETERMINE THE 'NUMBER POL TANKERS%' ON HAND AND ALIVE FOR THAT  FUEL TYPE
 634    DETERMINE THE BRIGADE POL POINT FUEL TYPE CAPACITY
 635    DETERMINE THE AMOUNT OF THE FUEL TYPE ON HAND IN THE BRIGADE POL POINT
 637    IF THE BRIGADE POL POINT CAPACITY MINUS THE AMOUNT ON HAND IS GREATER THAN A
         'TANKER LOAD%'
 639       DETERMINE THE ROUND TRIP OF A TANKER TO THE DISCOM POL POINT
 640       SCHEDULE RS_TANKER_RETURN-------------------------------------->( 27)
 641       SUBTRACT ONE FROM THE 'NUMBER POL TANKERS%' ON HAND FOR THAT FUEL TYPE
 643    ENDIF
 644    IF THERE IS A BATTALION FUEL TRUCK IN THE BRIGADE POL QUEUE
 645       IF THE AMOUNT OF THE FUEL TYPE ON HAND IS GREATER THAN '100% OF THE FUEL
            NEEDED'
 647          TAKE THE NEXT FUEL TRUCK IN THE BRIGADE POL QUEUE
 648          UPDATE BATTALION FUEL TRUCK FUEL TYPE ATTRIBUTE BY THE AMOUNT OF FUEL NEEDED
 650          DECREMENT THE BRIGADE POL POINT FUEL TYPE ATTRIBUTE BY THE AMOUNT OF FUEL
               NEEDED
 652          SCHEDULE RS_POL_LEAVE------------------------------------------>( 26)
 653       ELSE
 654          SET THE REFUEL POINT TO IDLE
 655       ENDIF
 656    ELSE
 657       SET THE REFUEL POINT TO IDLE
 658    ENDIF
 659 ENDEVENT
```

```
LINE
  660 EVENT RS_TANKER_RETURN
  661     ********************************************************************************
  662     * THIS EVENT IS SCHEDULED FOR ALL EMPTY DISCOM POL TANKERS AT THE BRIGADE POL   *
  663     * POINT TO ACCOUNT FOR THE TIME IT WOULD TAKE TO MAKE A ROUND TRIP TO THE DISCOM *
  664     * POL POINT.                                                                    *
  665     ********************************************************************************
  666     UPDATE NUMBER OF BRIGADE TANKERS ALIVE
  667     UPDATE 'NUMBER POL TANKERS#' ON HAND
  668     ADD QUANTITY DELIVERED TO BRIGADE POL POINT FUEL TYPE ATTRIBUTE
  669 ENDEVENT
```

```
670 EVENT RS_CSA_CONVOY
671    ********************************************************************
672    * THIS EVENT IS SCHEDULED PERIODICALLY TO SIMULATE THE ARRIVAL OF CCRPS *
673    * AMMUNITION CONVOYS AT THE ATP.                                     *
674    ********************************************************************
675    SCHEDULE RS_CSA_CONVOY TO ARRIVE 'EVERY SPECIFIED TIME INTERVAL%'---------->( 28)
676    DO FOR EACH AMMUNITION TYPE
677       UPDATE THE ATP AMMUNITION TYPE ATTRIBUTES BY THE AMOUNT DELIVERED
678    LOOP
679 ENDEVENT
```

```
LN  PAGE

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 2      2  .  RS_EVALUATE
 3            ** EXPANDED ON LINE   1
 4      4  .  RS_BATTALION_LOGIC
 5      5  .  .  RS_ALLOCATE
 6      7  .  .  .  RS_UPDATE
 7      8  .  .  .  RS_MISSION
 8      9  .  .  .  .  RS_START_MOVE
 9     10  .  .  .  .  .  LOC
10     11  .  .  .  .  RS_CONVOY_ARRIVE
11     12  .  .  .  .  .  RS_OFFLOAD_CACHE
12      9  .  .  .  .  .  .  RS_START_MOVE
13                           ** EXPANDED ON LINE   8
14     14  .  .  .  .  .  .  RS_CV_ARRIVE
15     16  .  .  .  .  .  .  .  RS_ENDLOAD
16     19  .  .  .  .  .  .  .  .  RS_END_MISSION
17     20  .  .  .  .  .  .  .  .  .  RS_TRUCK_UPDATE
18      9  .  .  .  .  .  .  .  .  .  .  RS_START_MOVE
19                                       ** EXPANDED ON LINE   8
20     21  .  .  .  .  .  .  .  .  .  .  RS_TRAINS_ARRIVE
21      9  .  .  .  .  .  .  .  .  .  .  .  RS_START_MOVE
22                                          ** EXPANDED ON LINE   8
23     22  .  .  .  .  .  .  .  .  .  .  .  RS_ATP_ARRIVE
24     23  .  .  .  .  .  .  .  .  .  .  .  .  RS_ATP_LEAVE
25      9  .  .  .  .  .  .  .  .  .  .  .  .  .  RS_START_MOVE
26                                                ** EXPANDED ON LINE   8
27     21  .  .  .  .  .  .  .  .  .  .  .  .  .  RS_TRAINS_ARRIVE
28                                                ** EXPANDED ON LINE  20
29     23  .  .  .  .  .  .  .  .  .  .  .  .  .  RS_ATP_LEAVE
30                                                ** EXPANDED ON LINE  24
31     24  .  .  .  .  .  .  .  .  .  .  .  .  RS_ASP_RETURN
32      9  .  .  .  .  .  .  .  .  .  .  .  .  .  RS_START_MOVE
33                                                ** EXPANDED ON LINE   8
34     21  .  .  .  .  .  .  .  .  .  .  .  .  .  RS_TRAINS_ARRIVE
35                                                ** EXPANDED ON LINE  20
36     22  .  .  .  .  .  .  .  .  .  .  .  .  RS_ATP_ARRIVE
37                                             ** EXPANDED ON LINE  23
38     25  .  .  .  .  .  .  .  .  .  .  .  RS_POL_ARRIVE
39     26  .  .  .  .  .  .  .  .  .  .  .  .  RS_POL_LEAVE
40      9  .  .  .  .  .  .  .  .  .  .  .  .  .  RS_START_MOVE
41                                                ** EXPANDED ON LINE   8
42     21  .  .  .  .  .  .  .  .  .  .  .  .  .  RS_TRAINS_ARRIVE
43                                                ** EXPANDED ON LINE  20
44     27  .  .  .  .  .  .  .  .  .  .  .  .  .  RS_TANKER_RETURN
```

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47     25  . . . . . . . . . . . . . . RS_POL_ARRIVE
48                                       ** EXPANDED ON LINE  38
49     21  . . . . . . . . . . . . . RS_TRAINS_ARRIVE
50                                      ** EXPANDED ON LINE  20
51     17  . . . . . . . . . . RS_FUEL
52     18  . . . . . . . . . . . RS_END_FUEL
53      9  . . . . . . . . . . . . RS_START_MOVE
54                                    ** EXPANDED ON LINE   8
55     19  . . . . . . . . . . . . RS_END_MISSION
56                                    ** EXPANDED ON LINE  16
57     17  . . . . . . . . . . . . RS_FUEL
58                                    ** EXPANDED ON LINE  51
59     14  . . . . . . . . . . . . RS_CV_ARRIVE
60                                    ** EXPANDED ON LINE  14
61      9  . . . . . . . . . . . RS_START_MOVE
62                                   ** EXPANDED ON LINE   8
63      9  . . . . . . . . . . RS_START_MOVE
64                                  ** EXPANDED ON LINE   8
65     14  . . . . . . . . . . RS_CV_ARRIVE
66                                  ** EXPANDED ON LINE  14
67     17  . . . . . . . . . RS_FUEL
68                                 ** EXPANDED ON LINE  51
69     19  . . . . . . . . . RS_END_MISSION
70                                 ** EXPANDED ON LINE  16
71      9  . . . . . . . . . RS_START_MOVE
72                                 ** EXPANDED ON LINE   8
73     14  . . . . . . . . . RS_CV_ARRIVE
74                                 ** EXPANDED ON LINE  14
75     20  . . . . . . . . RS_TRUCK_UPDATE
76                                ** EXPANDED ON LINE  17
77      9  . . . . . . . RS_START_MOVE
78                               ** EXPANDED ON LINE   8
79     14  . . . . . . . RS_CV_ARRIVE
80                               ** EXPANDED ON LINE  14
81     19  . . . . . . . RS_END_MISSION
82                               ** EXPANDED ON LINE  16
83     11  . . . . . . . RS_CONVOY_ARRIVE
84                               ** EXPANDED ON LINE  10

85     28  RS_CSA_CONVOY
86     28  .  RS_CSA_CONVOY
87            ** EXPANDED ON LINE  85
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RS_UPDATE		
PAGE 5	ROUTINE RS_ALLOCATE	132 135
PAGE 6	ROUTINE RS_ALLOCATE	140
PAGE 7	ROUTINE RS_UPDATE	148

IDENTIFIER	MODULE NAME	LINE NUMBERS			
ABORT*MISSION*THRESHOLD%					
PAGE 11	EVENT RS_CONVOY_ARRIVE	207			
PAGE 14	EVENT RS_CV_ARRIVE	294			
PAGE 16	EVENT RS_ENDLOAD	356			
AREA*SUPPRESSION*INDEX					
PAGE 11	EVENT RS_CONVOY_ARRIVE	206	207		
PAGE 14	EVENT RS_CV_ARRIVE	293	294		
PAGE 16	EVENT RS_ENDLOAD	355	356		
COMPANY*LCN					
PAGE 2	EVENT RS_EVALUATE	55			
PAGE 3	EVENT RS_EVALUATE	57			
PAGE 4	ROUTINE RS_BATTALION_LOGIC	68	70	73	
PAGE 5	ROUTINE RS_ALLOCATE	99	104	133	
PAGE 6	ROUTINE RS_ALLOCATE	138			
COMPANY*SUPPLY*STATUS					
PAGE 3	EVENT RS_EVALUATE	57			
PAGE 4	ROUTINE RS_BATTALION_LOGIC	73			
PAGE 5	ROUTINE RS_ALLOCATE	104			
PAGE 8	EVENT RS_MISSION	173			
PAGE 19	ROUTINE RS_END_MISSION	446			
COMPANY*RESUPPLY*TACTIC%					
PAGE 4	ROUTINE RS_BATTALION_LOGIC	78			
PAGE 5	ROUTINE RS_ALLOCATE	99			
PAGE 11	EVENT RS_CONVOY_ARRIVE	208	209		
COMPANY*SUPPRESSION*INDEX					
PAGE 4	ROUTINE RS_BATTALION_LOGIC	83	84		
DEGREE*OF*RISK%					
PAGE 4	ROUTINE RS_BATTALION_LOGIC	81	84		
LOOKUP*TABLE%					
PAGE 2	EVENT RS_EVALUATE	48	55		
PLATOON*LCN					
PAGE 2	EVENT RS_EVALUATE	48			
TIME*UNTIL*THE*NEXT*EVALUATION%					
PAGE 2	EVENT RS_EVALUATE	18			
VEHICLE*LCN					
PAGE 2	EVENT RS_EVALUATE	25	29	33	35
PAGE 16	EVENT RS_ENDLOAD	341			
PAGE 18	EVENT RS_END_FUEL	408			

IDENTIFIER	MODULE NAME	LINE NUMBERS	
ABORT*MISSION*THRESHOLD%			
PAGE 11	EVENT RS_CONVOY_ARRIVE	207	
PAGE 14	EVENT RS_CV_ARRIVE	294	
PAGE 16	EVENT RS_ENDLOAD	356	
ALLOCATION PROCESS TIME LAG%			
PAGE 6	ROUTINE RS_ALLOCATE	146	
ASP TRIP LENGTH%			
PAGE 22	EVENT RS_ATP_ARRIVE	534	
COMPANY*RESUPPLY*TACTIC%			
PAGE 4	ROUTINE RS_BATTALION_LOGIC	78	
PAGE 5	ROUTINE RS_ALLOCATE	99	
PAGE 11	EVENT RS_CONVOY_ARRIVE	208	209
DEGREE*OF*RISK%			
PAGE 4	ROUTINE RS_BATTALION_LOGIC	81	84
EVERY SPECIFIED TIME INTERVAL%			
PAGE 28	EVENT RS_CSA_CONVOY	675	
LOOKUP*TABLE%			
PAGE 2	EVENT RS_EVALUATE	48	55
NUMBER POL TANKERS%			
PAGE 26	EVENT RS_POL_LEAVE	632	641
PAGE 27	EVENT RS_TANKER_RETURN	667	
NUMBER REFUEL POINTS%			
PAGE 25	EVENT RS_POL_ARRIVE	593	
TANKER LOAD%			
PAGE 26	EVENT RS_POL_LEAVE	637	
TIME*UNTIL*THE*NEXT*EVALUATION%			
PAGE 2	EVENT RS_EVALUATE	18	
100% OF THE FUEL NEEDED			
PAGE 25	EVENT RS_POL_ARRIVE	595	
100% OF THE FUEL NEEDED			
PAGE 26	EVENT RS_POL_LEAVE	645	
25% OF AMMUNITION OR 30% FUEL CAPACITY			
PAGE 2	EVENT RS_EVALUATE	23	
25% OF A TRUCK LOAD			
PAGE 6	ROUTINE RS_ALLOCATE	138	
25% OF THE AMMUNITION/FUEL REQUESTED			
PAGE 5	ROUTINE RS_ALLOCATE	107	
50% OF AMMUNITION OR 65% FUEL CAPACITY			
PAGE 2	EVENT RS_EVALUATE	27	
50% OF A TRUCK LOAD			
PAGE 5	ROUTINE RS_ALLOCATE	133	

IDENTIFIER	MODULE NAME	LINE NUMBERS
PAGE 21	EVENT RS_TRAINS_ARRIVE	490
50% OF THE	AMMUNITION NEEDED	
PAGE 22	EVENT RS_ATP_ARRIVE	521
50% OF THE	AMMUNITION NEEDED	
PAGE 22	EVENT RS_ATP_ARRIVE	534
90% OF AMMUNITION OR 80%	FUEL CAPACITY	
PAGE 2	EVENT RS_EVALUATE	31

APPENDIX B: Suppression Logic

1. Introduction:

The play of suppression in STAR is designed to represent the effects of direct and indirect fire on delaying element functions. The play of suppression is parametric and the effects can be altered by the input parameters supplied by the user.

2. Assumptions:

a. The suppressive effect of a round is a decaying phenomenan, and can be represented as a time delay in the performance of element functions.

b. The suppressive effect of indirect fire is a function of the proximity of the impact to the target, and whether or not the round's impact is observed by the target.

c. Different rounds have different suppressive effects and can be represented by different round "weights".

d. The suppressive effect of direct fire rounds occurs if the round lands short, or if the round hits the target. Rounds which miss over a target are assumed to be unobserved and have no suppressive effect.

e. The susceptability to suppression of a particular weapon system can be represented by a parameter, and all similar weapon systems in the simulation have a common parameter

e.g. all XM1's have a $\lambda = 1$

all BMP's have a $\lambda = 1.3$

f. The suppressive effects of a round fired are uniform for all vehicles in the target's platoon. (subject to different λ's for different weapon systems within the same platoon).

c. Rounds are assumed to have no suppressive effect after 2 minutes of simulation time.

d. Each r_i has associated with it a factor d_i which represents the decaying effect of suppression over time.

For example: $d_1 = 1$

$d_2 = .5$

$d_3 = .2$

$d_4 = .05$

The total effect of rounds fired at a platoon can then be represented by an adjusted value R

$$R = r_4d_4 + r_3d_3 + r_2d_2 + r_1d_1$$

$$= .05r_4 + .2r_3 + .5r_2 + r_1$$

e. The suppressive effect of rounds on a particular weapon system is represented by a parameter λ.

i.e. $\lambda = 1$ for XM1's

$\lambda = 2$ for BMP's

$\lambda = 10$ for dismounted infantry

f. A time delay can then be calculated based on R, and λ

$$\text{time delay } (t) = e^{R\lambda} - 1$$

This time delay value is then used to effect the functions of a particular element in the simulation.

g. The weighting of indirect fire rounds is represented as a function of proximity to the target and whether or not the impact of the round is observed by the target. The technique used is explained in a paper entitled "Suppression Methodology" (attached) and will not be further amplified herein.

3. Functions Represented:

   a. The effect of suppression on detection results in detections being delayed or eliminated.

   b. The effect of suppression on firing is to extend the lay/load time at target selection, and to increase aim error upon firing.

   c. The effect of unaimed direct fire is not currently implemented.

   d. The effects of suppression on unit or individual vehicle movement is not currently implemented.

4. Technique:

   a. The basic unit on which the suppression functions operate is the platoon. The suppressive of each round fired is represented by a "weight".

      i.e. 120mm APDS weight = 1.0

      73mm HEAT weight = .65

      152mm Arty weight = 1.3

   b. The weights of all rounds fired at platoon elements are summed up and stored as attributes of the PLATOON.LEADER permanent entity. These attributes are reset every 30 seconds of the simulation.

      i.e. $r_i = r_{i-1}$ $\quad i = 1$ to 4

      where each r_i is the total suppressive weight of all rounds effecting elements of the platoon during a 30 second portion of the battle.

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